ASTRONOMY

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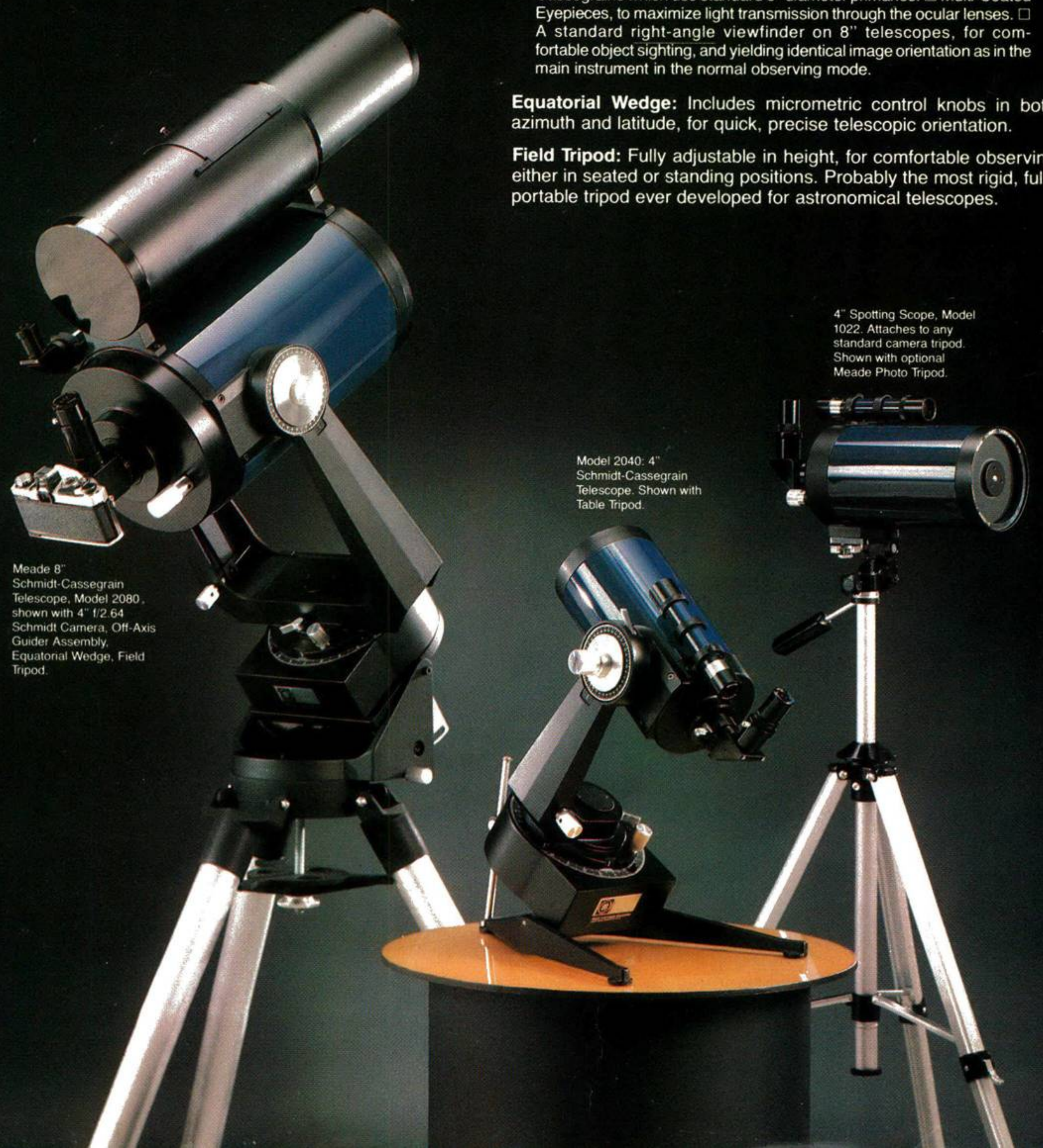

4" Spotting Scope, Model 1022. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

Model 2040: 4" Schmidt-Cassegrain Telescope. Shown with Table Tripod.

Meade 8" Schmidt-Cassegrain Telescope, Model 2080, shown with 4" f/2.64 Schmidt Camera, Off-Axis Guider Assembly, Equatorial Wedge, Field Tripod.

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Equatorial Wedge 4"/8"	**60**
Field Tripod 4"/8"	**160**
Table Tripod 4"	**40**
Table Tripod 8"	**50**
Model 1020: 1000mm f/10 Telephoto Lens	**325**
Model 1022: 4" Spotting Scope	**395**
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Orders: May be placed by mail, or by telephone at **(714) 556-2291**, or visit our Costa Mesa factory/showroom.

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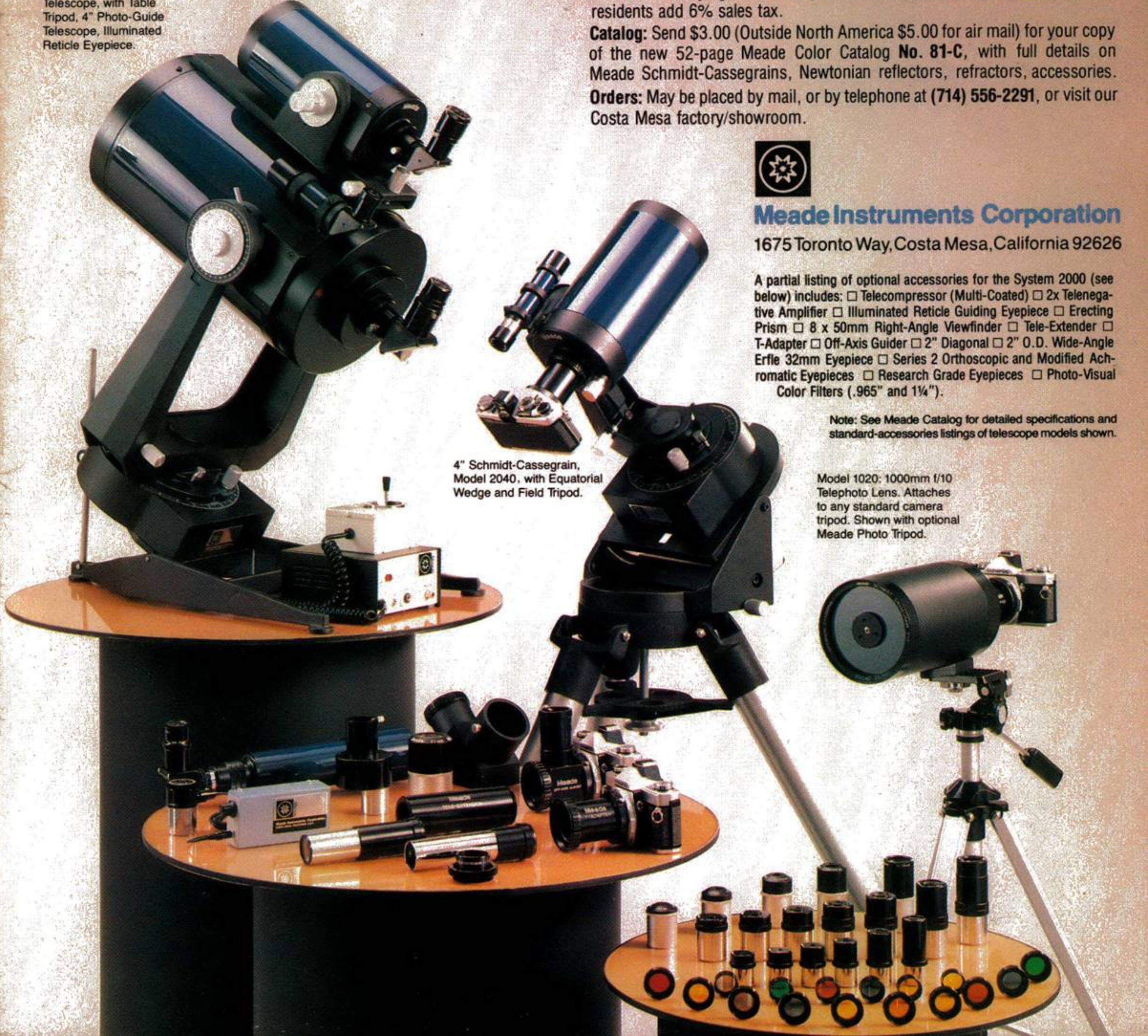

Model 2080: 8" Schmidt-Cassegrain Telescope, with Table Tripod, 4" Photo-Guide Telescope, Illuminated Reticle Eyepiece.

4" Schmidt-Cassegrain, Model 2040, with Equatorial Wedge and Field Tripod.

Model 1020: 1000mm f/10 Telephoto Lens. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

A partial listing of optional accessories for the System 2000 (see below) includes: ☐ Telecompressor (Multi-Coated) ☐ 2x Telenegative Amplifier ☐ Illuminated Reticle Guiding Eyepiece ☐ Erecting Prism ☐ 8 x 50mm Right-Angle Viewfinder ☐ Tele-Extender ☐ T-Adapter ☐ Off-Axis Guider ☐ 2" Diagonal ☐ 2" O.D. Wide-Angle Erfle 32mm Eyepiece ☐ Series 2 Orthoscopic and Modified Achromatic Eyepieces ☐ Research Grade Eyepieces ☐ Photo-Visual Color Filters (.965" and 1¼").

Note: See Meade Catalog for detailed specifications and standard-accessories listings of telescope models shown.

USA

ASTRONOMY

Vol. 9, No. 8 August 1981

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

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Cover: America's first Space Shuttle, *Columbia*, left Earth from Pad A at the Kennedy Space Center's Complex 39 on April 12, 1981, and ushered in a new era in space exploration. These pages: After assembly in the VAB, the Shuttle began its slow journey to the launch pad. Photographs courtesy of the National Aeronautics and Space Administration.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 411 E. Mason St., P.O. Box 92788, Milwaukee, WI 53202. Telephone: (414) 276-2689.

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Controlled circulation postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Send editorial inquiries and submissions to the address above. Not responsible for unsolicited materials. Questions about subscriptions and product orders: (414) 276-2689 weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue.Subscription price: 1 year, $18.00. All foreign: add $5.00 per year; please remit in U.S. funds. AstroMedia staff: Teresa Banks, Jacquelyn Berger, Stephanie Kiel, Clarita Manto, Maggie Martinez, Bruce Precourt, Susan Robinson. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.

Triumph over Tribulation

SPACE SHUTTLE

by Michael Boelke

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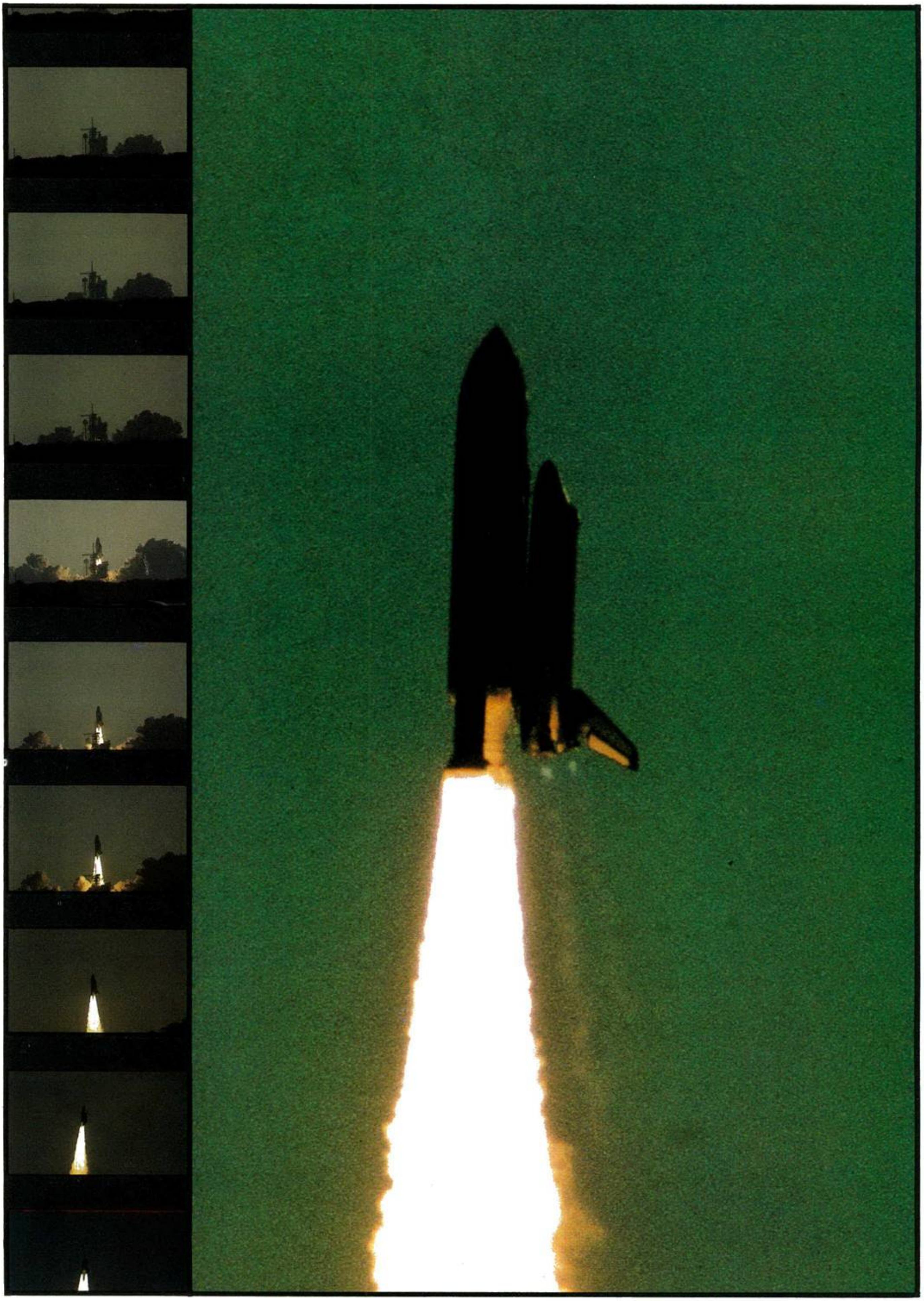


The story of the Space Shuttle *Columbia* began October 4, 1957 when the Soviet Union launched sputnik 1. Although Sputnik's launch pales in comparison to the monster rockets that followed it, it heralded the beginning of a race to the Moon measured in dollars spent instead of accomplishments. It was a race the United States won easily.

In 1969, NASA was winding down ten years of spending — spending that ultimately sent six American missions to the Moon. Yet despite its decade of growth and success, NASA's slice of the budget was shrinking. Faced with an uncertain future the space agency sought new goals — something other than unmanned planetary probes — to justify its existence.

Apollo had been expensive — very expensive. Inside the space agency, the wisdom of using throwaway multi-million dollar Apollo-style rockets that disintegrated in fiery re-entry was being closely scrutinized. In fact, the whole costly one-time-only Apollo philosophy was a bit shaky. Apollo was fine for a first step into space. But for the future, we needed a less expensive way to explore the universe.

In 1969, NASA took a faltering step toward the future and revived the old idea of a re-usable spaceship — an economical vehicle that would give more return for the money spent.

At the time, Congress was attempting to cope with a country deeply split over the Vietnam war and angered over its government's inability to control inflation. The politicians simply didn't want to thrust another multi-billion-dollar project at the public with an unpopular conflict already draining the economy. So the first proposal for studies that could have led to the first cheap and fully re-usable space vehicle died in a tie vote in Congress.

Frustrated, some of the farsighted planners at NASA who knew the potential for a re-usable spaceship looked for allies. The "space truck," as the Shuttle is sometimes called, would make lifting off into Earth orbit routine. The potential was enormous, but, with few advocates holding public office, NASA gathered its clout from another source — the U.S. Air Force. Unfortunately the backing of the Air Force came with a high price tag.

The Air Force wanted modifications in the Shuttle's design. It wanted a larger payload bay capable of handling advanced 65,000 pound military satellites, and it wanted separate launch and landing facilities at Vandenberg Air Force Base in California. The modifications would increase the proposed cost of the Shuttle by about 25 percent and they promised to cause even greater technological headaches in an already massive, expensive and difficult project. With nowhere else to turn, the politically scarred space agency accepted Air Force support — and a new round of engineering problems.

In 1970, Congress allocated funds to design a space shuttle. Within a year, design prototypes were being tested in model form.

By 1971, NASA was in love with re-usable spaceships. Engineers had come up with a totally re-usable vehicle, a beautiful design without wasteful throwaway boosters. But developing such a shuttle was expensive — and once again a faltering U.S. economy thwarted the program. With a price tag of ten billion dollars, the system was too expensive. The engineers were told to think again, and think cheaper.

The only cheaper alternative proved to be TAOS — Thruster Assisted Orbiter System — a system that is only partially re-usable. This is our present shuttle system, an orbiter with two recoverable solid rocket fuel boosters and an expendable external tank from which the orbiter's three main engines draw fuel.

Giving up its love affair with a totally re-usable system didn't appeal to the space agency, but a sagging economy and nonsupportive politicians teamed up and made the semi-expendable system the only program NASA could hope to sell to Congress in 1972.

There was another problem: cost estimates ran over 8 billion dollars. Once again, Congress turned a deaf ear to the agency's pleas, and offered NASA 5 billion dollars for the project — take it or leave it. Desperate to begin work, NASA accepted the lower figure. The agency dropped the highly effective development policies learned during the Apollo program, and asked its engineers to economize. It asked them to forego the elaborate part-by-part testing of the past and take the "do it and get it right the first time" approach — or else. The target date for the first launch was set for March 1979.

The research and development to construct the Shuttle proved to be a job of creating one "first" after another. It wasn't a case of inventing a few new parts: the complexity of the Shuttle required massive think tanks and computer aided design. But there wasn't enough money for a lot of careful testing. There would be a few big gambles.

For the first time ever, a manned vehicle would use a combined thrusting system. Fully fueled and loaded, a Space Shuttle would weigh 4.4 million pounds. It would require a propulsion system like no

Liftoff! With his camera set at two frames per second, Mike Boelke captured this sequence of launch events: a great cloud of smoke from engine ignition, a brilliant flame lighting the surroundings, and then the Shuttle's rapid progress into the sky. All photographs with a 400mm telephoto lens.

Launch

Check the cameras again for the one hundredth time. Now wipe the lens and cover it up to keep the dew off.

They were all there. Every medium you could think of was represented, and a lot you never would. Television, newspaper and magazine photographers were all doing the same things — checking their cameras, swatting mosquitos, and telling tales about those really great previous assignments.

But there were feelings that this would be the one assignment they would talk about for years. The long-time pros tried to play the part of the seasoned veterans with fascinating stories, but it was obvious they other vehicle before. The orbiter main engines would use 6 parts liquid oxygen (LOX) to 1 part liquid hydrogen (LH_2) and supply 1.4 million pounds of thrust. Two solid rocket boosters, favored by the military because of their storability, would assist the main engines. They would add 5.3 million pounds of thrust for a total of 6.7 million pounds.

The main engines alone proved to be a major technological challenge, and were blamed for most of the delays in the Shuttle's progress.

But the design of the Shuttle engines broke new ground in engineering. Pressures within their combustion chambers would exceed 3000 PSI. Temperatures would run as high as 6000° F — hotter than the boiling point of most metals. During test firings, these conditions would shatter ball bearings, crack turbine blades and cause half a dozen fires during the development of the engines. They incorporated a new method of steering — thrust vectoring — made possible by an elaborate gimbal bearing assembly that transmits thrust loads and permits direction control of the actual thrust force. After months of "white knuckle" problems and a Senate inquiry, the main engine development was finally put right by a team from the National Academy of Sciences. In spite of mechanical, technological and design headaches that caused months of delay, the Shuttle main engines today are the epitome of space propulsion hardware.

The boosters also represent new engineering solutions to severe challenges. Never before had solid fuel rockets been considered safe enough to transport humans — yet the Space Shuttle relies on them. The spent boosters are recovered after launch, and refurbished and refueled with an atomized aluminum powder fuel and an ammonium perchlorate oxidizer. They are the only re-usable part of the Shuttle system aside from the orbiter itself. Why had solid-fuel rockets never before been used for a manned mission? Unlike liquid-fuel rockets, which can be throttled, once ignited, solid rockets are on for good. They are used strictly to provide the "muscle" to get the Shuttle off the ground. The main engines could hardly move the Shuttle's immense weight.

After being grounded for six years by a weak national economy and a disinterested Congress, the American astronaut corps once again orbited Earth. With handheld cameras, they returned the scenes shown on next and following pages to Earthbound viewers. Opposite page: Looking southwest, the Shuttle crew saw large sections of Arizona and Utah, including Lake Powell in the foreground and the Colorado and San Juan Rivers flowing toward the Grand Canyon in the upper part of the frame. Next two pages: Through the aft window of the flight deck, the Shuttle's vertical stabilizer cut across this magnificent swirl of clouds over the Pacific Ocean. Page 14: On the other side of the globe, the blue waters of the Strait of Hormuz, the Persian Gulf, and the Gulf of Oman contrast with the grey and pink deserts of Iran and the United Arab Emirates. Orbital photography covers vast amounts of territory very quickly. NASA photographs.

Of course the technological problems were not confined to the propulsion system. Of all the problems to slow the Shuttle, the most tedious proved to be the thermal protective tiles. They are the single most important element determining the re-usability of the orbiter.

The 34,000 plus tiles that cover approximately three quarters of the orbiter's surface serve as a barrier against the intense heat generated by friction during re-entry. Made of 90 percent air and 10 percent pure silica fibers, the borosilicate glass outer surface disperses 95 percent of the heat while the interior absorbs the remaining 5 percent. At re-entry temperatures as high as 2,750° F, a missing or damaged tile could prove extremely dangerous. Such heat could burn through the orbiter's aluminum and graphite epoxy skin, and destroy vital components inside the craft — including the astronauts.

Each tile has its own computer-coordinated part and location number and its own specific and individual history. No two are alike. The tiles are even cut and formed with the aid of a computer in order to tightly conform to the orbiter's aerodynamic shape. Yet one of the major problems with the tiles was sticking them to the orbiter. And the tile problem came as a surprise: after a flight to Kennedy Space Center piggyback on a 747 jumbo jet, *Columbia*

couldn't hide their excitement. Their anxious glances were directed toward the assignment, STS-1, the Space Shuttle *Columbia* and its maiden launch.

The minutes seemed to pass slowly with Mission Control counting down and giving periodic status reports over the public address system. At T minus 2 hours and 15 minutes, Mission Control announced a two hour built-in hold and said that the flight crew was having breakfast. During the 48 hour postponement, the two astronauts, Young and Crippen, had spent their time relaxing and practicing shuttle-type landings in a specially designed executive jet.

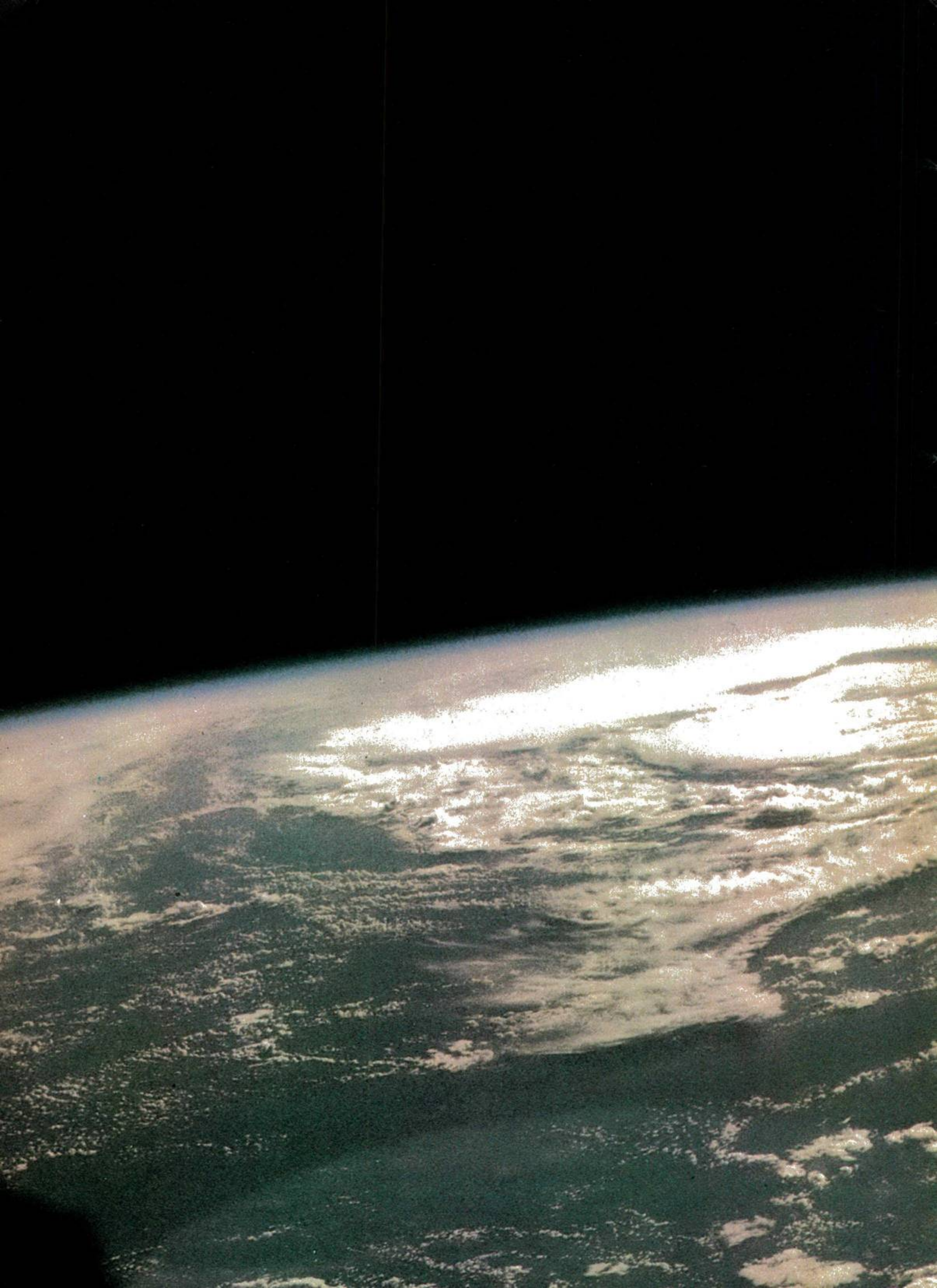
As the time until liftoff grew shorter, excitement increased with nervous talking and camera checking. At T minus 20 minutes everyone had been on their feet and squinting through camera viewfinders for over an hour.

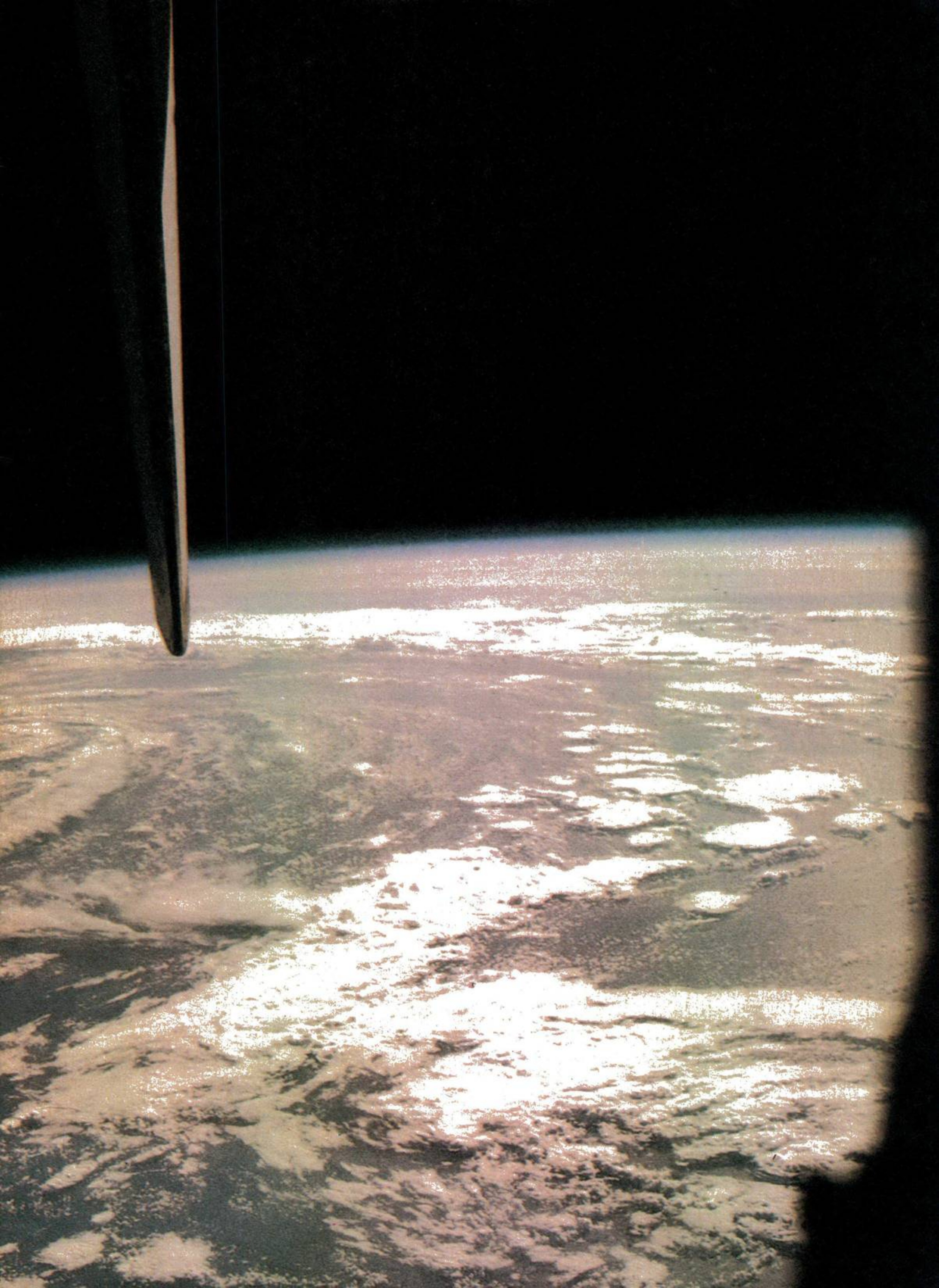
When the countdown reached T minus 9 minutes, the last built-in hold of 10 minutes began. Announcements by Mission Control brought no bad news as had the previous count at T minus 9 minutes. When the final built-in hold was over and it was a go for launch, a tremendous cheer went up from the VIP and media crowd.

The anticipation was like a tense knot in the crowd as positive status reports continued from Mission Control. T minus 3 minutes 10 seconds and the orbiter was on internal power. The crowd cheered louder and harder.

At T minus 2 minutes, the countdown began to come at 15-second intervals. At T minus 15 seconds, the countdown came at 1-second intervals. Shouts of "go, go, go, sweetheart" and "come on baby" were heard from everyone. The main engines started with four seconds left to go. As a cloud began to rise from the base of the launch pad, all that could be heard was the roar of shutters as motor drives began to eat film.

Suddenly a bright yellow light appeared at the base of the shuttle





looked as if it had a pox. Over 7,000 of the tiles had come off during the trip.

NASA engineers were panic stricken. If that many tiles came off during a simple cross-country flight, what would happen during a launch when the tiles were treated to massive acoustic and dynamic vibrations? The techniques used to bond the tiles to the Nomex felt — which is directly bonded to the orbiter's skin — were at fault.

Nomex felt is designed to absorb the stress encountered by the orbiter structure. Without the felt pad, the brittle tiles could easily be damaged. The solution was to "densify" the inside surface of the tile so the glue would stick better. By painting a densification material onto the tiles, the silicone resin cement had a better surface for adhesion.

Besides the difficult technical problems, the Shuttle program has been harried by political forces. Opponents of NASA argue that in an era of economic instability, space exploration is an expensive luxury. Senator Proxmire of Wisconsin, for example, has said one problem arises from the promise NASA made to Congress — that 5 billion dollars would get the Shuttle off the ground. The Shuttle did cost more than five billion dollars, but if inflation since that original 1970 estimate — made in 1970 dollars — is taken into account, the estimate would have been 11 billion 1981 dollars.

Furthermore, cost cutting contributed to raising the cost of the Shuttle program. Developing a new concept such as the Space Transportation System (STS) is an immense undertaking. Forced to design to cost, NASA and its contractors found that new technological solutions were almost impossible — not because they were impossible to do, but because they cost too much money to explore. When NASA began the move into shuttle development, its funding was minimal. The shortage of money brought a shortage of planning, and finally, expensive problems.

Principal customer for the Shuttle is the United States military — slated to be on-board for three quarters of the presently scheduled operational launches. The military role in Shuttle costs is considerable, and the Shuttle is a necessity for military satellite launches. However, when asked to pay for their participation by supporting development costs, military spokesmen say they cannot justify the funds.

The non-military benefits from the Shuttle are obvious, but seldom mentioned. Concentrated technical advancement cannot be accomplished economically by private enterprise. NASA's design and development efforts in aerospace generate a transfer of know-how to almost all fields of science. But the benefits are difficult to trace because they are thoroughly integrated into our lives. These

Landing

As launch pad delays in the maiden voyage of the Space Shuttle *Columbia* mounted from minutes to hours to days, my thoughts drifted from the images on the television screen to contemplation of Vladimir Kovalenok and Victor Savinykh sailing confidently overhead aboard the Salyut-6 space station. They no doubt chuckled amiably and told American computer jokes as they continued the most advanced and successful space operation in history.

But when STS-1 finally leapt off the pad on a curving tower of smoke from the SRBs and disappeared into the deep blue of an early morning sky, I forgot all about the Soyuz T-4 cosmonauts. America was back in space — and tomorrow morning we could leave for the NASA Dryden Flight Research Center at Edwards Air Force Base to see that very same speck of metal and men return!

But euphoria had to be forgotten as the hustle and bustle of preparation reached an almost unbearable level of confusion:

as it started to rise. The *Columbia* seemed to jump from the pad. The emotionally charged crowd was screaming encouragement as if their voices would help lift the shuttle into orbit. Arms were in the air punching fists at the sky, and mouths were agape as the sound finally reached us from three miles away. I heard a low roar and then felt a concussion that made my pants legs flap.

The *Columbia* climbed on a column of white contrail and spewed a tail of fire four times its own length. Then it slowly rolled over on its back and was soon out of sight, leaving behind wide grins, shrieks of joy and tears of happiness.

One fellow, who had witnessed an Apollo launch, described the shuttle's effort as "almost polite." Another man compared the launch with the birth of his son.

For myself, witnessing the maiden launch was, without doubt, the single most exciting experience of my life. To have been there and recorded a moment in history that could affect the entire future of man was extremely humbling. I felt a shared sense of accomplishment and experience with these strangers.

The potential capabilities of the space shuttle can only be hampered by the boundaries of man's imagination. We must direct our energies and resources to either a ground oriented world or place our priorities in the direction of space exploration.

With earth resources becoming exhausted, population increasing at an unstoppable pace, and planetary energy supplies dwindling faster than replacements can be found, something must be done. The Space Shuttle *Columbia* is just the beginning.

Man needs the arousal and discipline of a common goal. Man must expand.

— *Michael Boelke*

confirming that everyone still wanted to go (no question about that!), arranging the car pool, watching live transmissions from space, packing, rushing to the bank only to discover that in all the excitement I'd forgotten it was Sunday — then rushing back home only to confront the sinking feeling accompanying news of missing tiles. We could go all that way only to hear of two dead astronauts . . . and a dead space program: two equally devastating thoughts. But nobody mentioned the possibility of not going.

Up at seven o'clock Monday morning to watch more live television. Young and Crippen looked fantastic floating in weightlessness, but those missing tiles had us worried. What if they didn't make it? America would lose her most experienced astronaut, and the Reagan Administration and Congress might drop their "support." Congress has never been enthusiastic about the Shuttle, and the Executive Branch keeps sending ominous signals with its cuts. My depression deepened.

I had to leave halfway through the network coverage in order to catch the bus to the university where the car pool would meet. I could have strangled the bus driver when he made me turn off my radio; petty rules transcend even the greatest advance in technology since the Neolithic Revolution.

It was hot on the long drive from Sacramento to Edwards under California's unrelenting Sun. I started the *ANALOG* serialization of Lee Correy's "Shuttle Down" — which did little to relieve my tension. Nor did the radio's steadfast refusal to reveal anything about anything. I take my fanatical devotion to space travel very seriously — and I had six years of "sense of wonder" bursting within me and no way to relieve the emotion. The car became a prison and the desert outside a thing of fear. What would happen on those sands tomorrow?

The first NASA sign pointing toward the public viewing site was all it took to revive our spirits. And we were just congratulating the legendary NASA efficiency when all of a sudden the signs vanished! No problem: simply follow the Edwards Air Force Base signs. We arrived at the gate and the guard waved us through barely glancing at our pass.

We promptly got lost. After wandering around the massive base for the better part of an hour, we found the visitor's center of the NASA Dryden Flight Research Center. It did not take us long to notice that ours was the only car without a press pass or a guest pass in the window. We found a NASA engineer directing traffic and asked him if this was the public viewing site.

It was not.

Did he know where we should go?

He did not. But he could check on his radio.

It turned out that we were not even supposed to be on the base!

Shuttle: a new role for astronauts

The Space Shuttle is the first spacecraft that requires the presence of a human to complete a successful mission. In earlier missions, the astronauts were more-or-less passengers. Many missions, in fact, would have been successful as unmanned attempts. The Shuttle will take off like a missile, orbit like a spacecraft and return like an airplane under the flight control of an astronaut turned pilot.

The sheer number of controls and displays the crew must know demonstrates the complexity of the orbiter control systems. Astronauts must be able to read, understand, and respond correctly to computer displays, clocks, timers, thousands of switches, controllers, meters, dials, and event lights.

But even a well-trained crew needs the assistance of on-board computers. For safety, there are four main computers — a "quad-redundant" system — that all process the same data. Each one is capable of performing about 325,000 operations per second. At all times, the computers must agree in their computations. If one does not agree with the others, it is turned off and the majority rules. As a last resort, a fifth "backup" computer acts as mediator, making the final decision. This in-depth computer backup system not only aids the astronauts, but also cuts the number of mission control personnel from the more than 500 used by the Apollo program to about 150 for the Space Shuttle.

The public viewing site was clear across the dry lake bed; we would have to drive all the way around the giant base even to get in line and we wouldn't have a snowball's chance in Hell of getting a good viewing spot.

But another engineer who had been listening quietly walked over and said that he wasn't a bit surprised that the Air Force boys at the gate weren't on the ball and let us in. Then he leaned conspiratorially over and whispered, "You don't know me. But you are on the base and if I were you I would stay put and watch from here. At worst, they'll throw you out and you can go on over the viewing area."

His friend looked doubtful but said nothing.

So we stayed. We were only a mile from the landing site versus the three miles for the public viewing site. We could hear the astronauts and mission control over the loudspeakers! We were not once checked for passes, nor was our car. So much for security on American air force bases.

Later we asked why the press stayed at the normal visitor's center while the public had to watch from so far away. The answer?

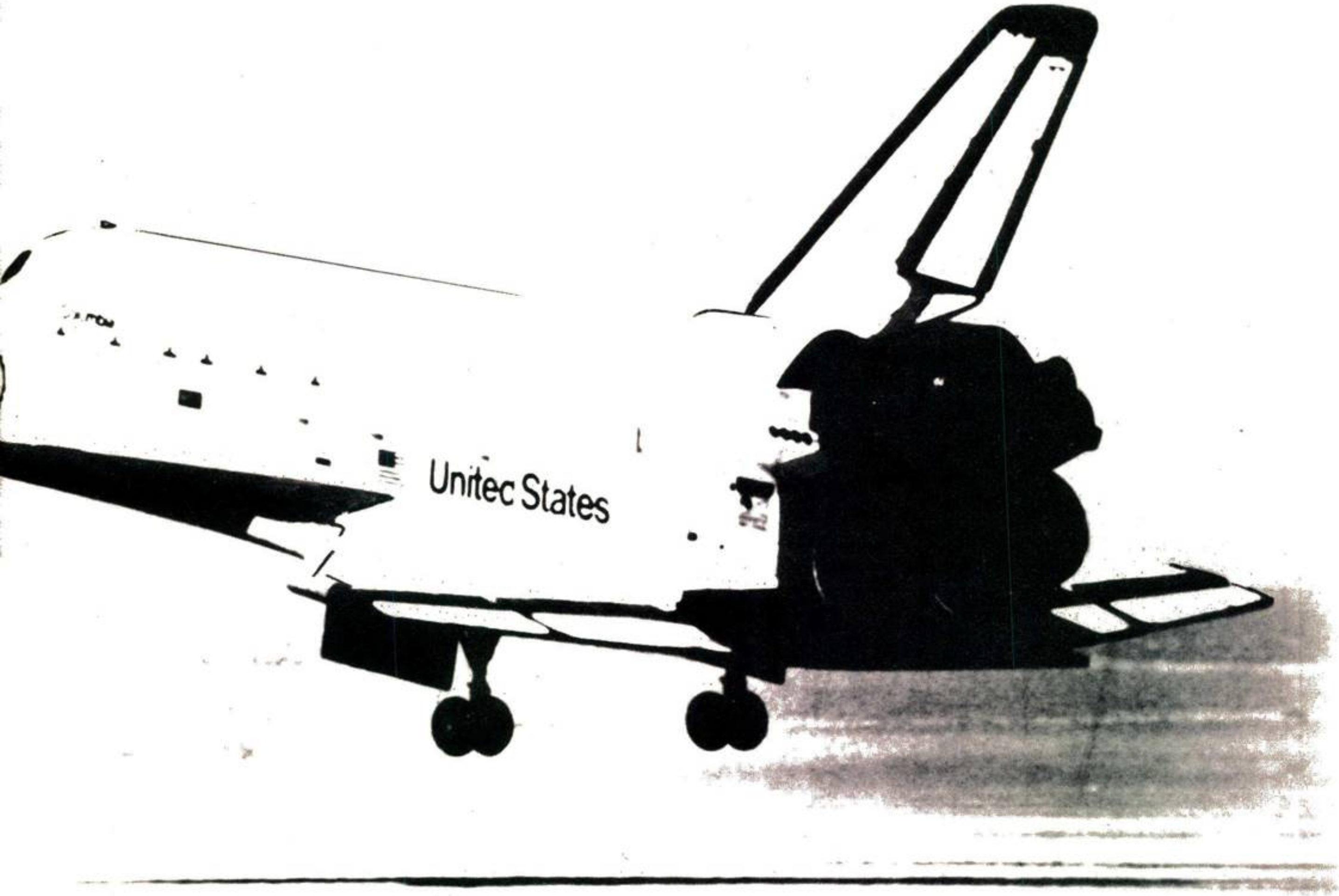
"Safety from poisonous fuel vapors that might escape from the orbital maneuvering engines." Evidently NASA is somewhat less concerned about poisoning the press then the public.

We set up camp beside the car. The public viewing site was a line of brilliant stars across a lake bed made brilliant by the desert moon. I must admit that while eating a dinner of stale peanut butter sandwiches, I felt at least a twinge of envy for the expense accounts that allowed the press people to fill the air with the smell of burning steaks and cheery little fires. The cold, the excitement, and dreams of failing tiles allowed me very little sleep.

In the morning, despite all the beautiful warm colors in the sky, it was freezing. I noticed Jerry Pournelle complaining about the lack of NASA road signs. I wondered if he had a press pass — or perhaps he was pulling the same sort of stunt that we were? I couldn't see whether he had a badge or not, but I thought he might have been holding that package just a bit tightly across his chest.

Finally, by nine o'clock, all our trials and tribulations had paid off. We stood clinging to the fence, straining out across the mirages toward an invisible runway and listened to the astronauts over the loudspeakers. Crowds of people waited breathlessly, frying in the brilliant unforgiving desert sun.

Then suddenly silence. *Columbia* had hit the atmosphere at 25 times the speed of sound and the resulting plasma blocked the S-band radio transmissions. Now was the proverbial moment of truth. Nobody knew the outcome. Would the tiles hold? Would our astronauts survive? Would the future hold a space program for the United States? The



expectant hush went on and on.

Mission Control: "*Columbia*? we should have a signal."

"What a way to come to California!" The cheer was deafening, like all high school homecoming games rolled into one. The tiles held, and Crippen could have his fun. The vehicle of the future had withstood its test. We had the potential for anything! A woman shouted: "Take that you stupid Russians!"

The rest was almost anticlimactic: white contrails of chase planes, the awesome double sonic boom, a shout — first sight of the Orbiter, the first real sight of the Orbiter between the chase planes, the incredibly rapid fall-glide and comet-tail of dust upon landing.

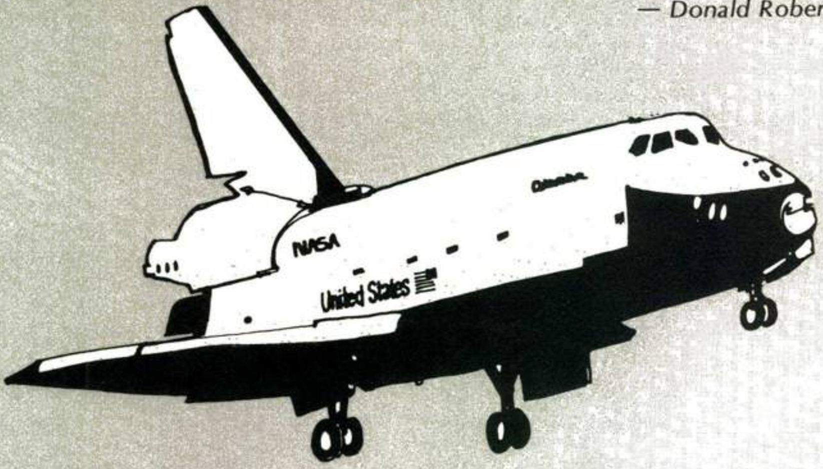
Later, back in the cafeteria, watching *Columbia* suffer silently through her initial checkout on the monitors, my euphoria was somewhat dampened when I overheard a cameraman, "I don't know what all the fuss is about: it's just like a plane. So what?"

I turned fast, ready to challenge him: nobody speaks of my *Columbia* as "just" a plane. But he was gone, off to his van and another boring assignment in some far corner of this world. So I answered him silently:

"But can't you see? Just an hour ago that 'plane' was in space, sweeping around an Earth it took man millions of years to explore. Every ninety minutes it circumnavigated our planet. Does that not strike you with wonder? Do you not feel the chill of the future in your spine? Do you not revel in the glory of man's newest accomplishment?"

"If you don't, then I feel sorry for you. You have no imagination, and you will never understand the power of the words: 'Reach for the stars!' "

— Donald Robertson



technological transfers have occurred in geology, communications, health services, transportation, astronomy, food processing and, of course, the exploration of the solar system.

Delays, hints of mismanagement, allegations of poor planning, and cost overruns make good stories for the media, but bad press for the Space Shuttle. Of course, the media need controversial news — but they have seldom attempted to understand in any depth the project they sought to investigate. The Shuttle, first and foremost, has been a research and development project: when *Columbia* sprang from its launching stand it was a "first." Never before had a spacecraft so undertested flown with a human on board. All previous manned United States space flights were preceded by unmanned flights that tested — and tested again — the theory and capabilities of the machines. *Columbia* had to function right the first time — and it did.

A faint streak of light in the pre-dawn sky, *Columbia* crosses southern Arizona on the morning of April 14, through the stars of the constellation Bootes. Photograph by William K. Hartmann.

The story of the Shuttle is not one of intrigue or mystery. It is a story of hard work with too little money, and brilliant, determined people with the foresight to press for what they knew to be right, and who possessed the humanity to forgive those with their eyes still on the ground.

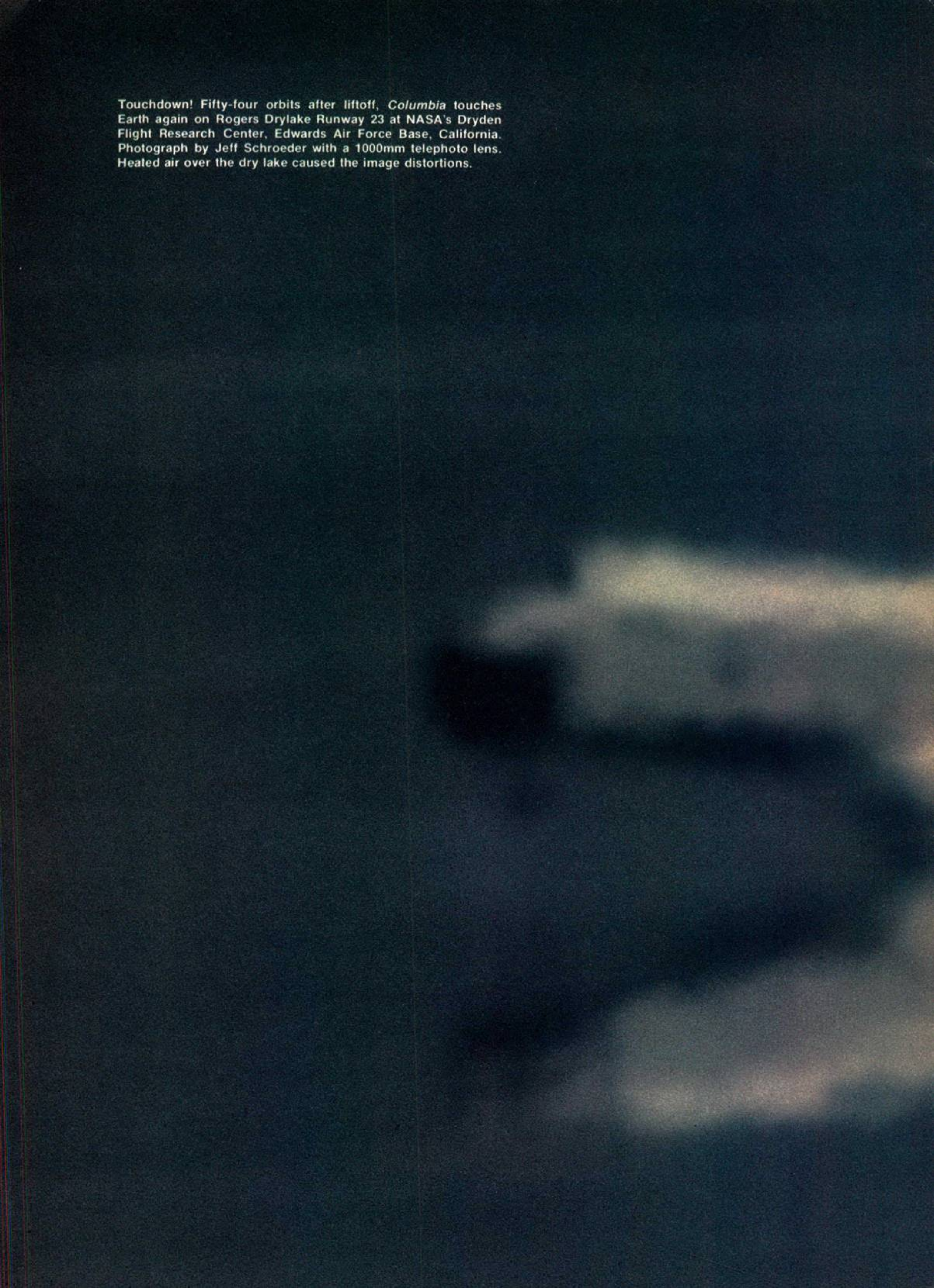
The United States hasn't had a manned space mission since Apollo-Soyuz in July 1975. That six year hold has, according to some experts, placed the U.S. far behind the Soviet Union in the continuing space race. However, the successful launch of the Shuttle suggests that the gap can be closed — if we don't abandon our space goals again.

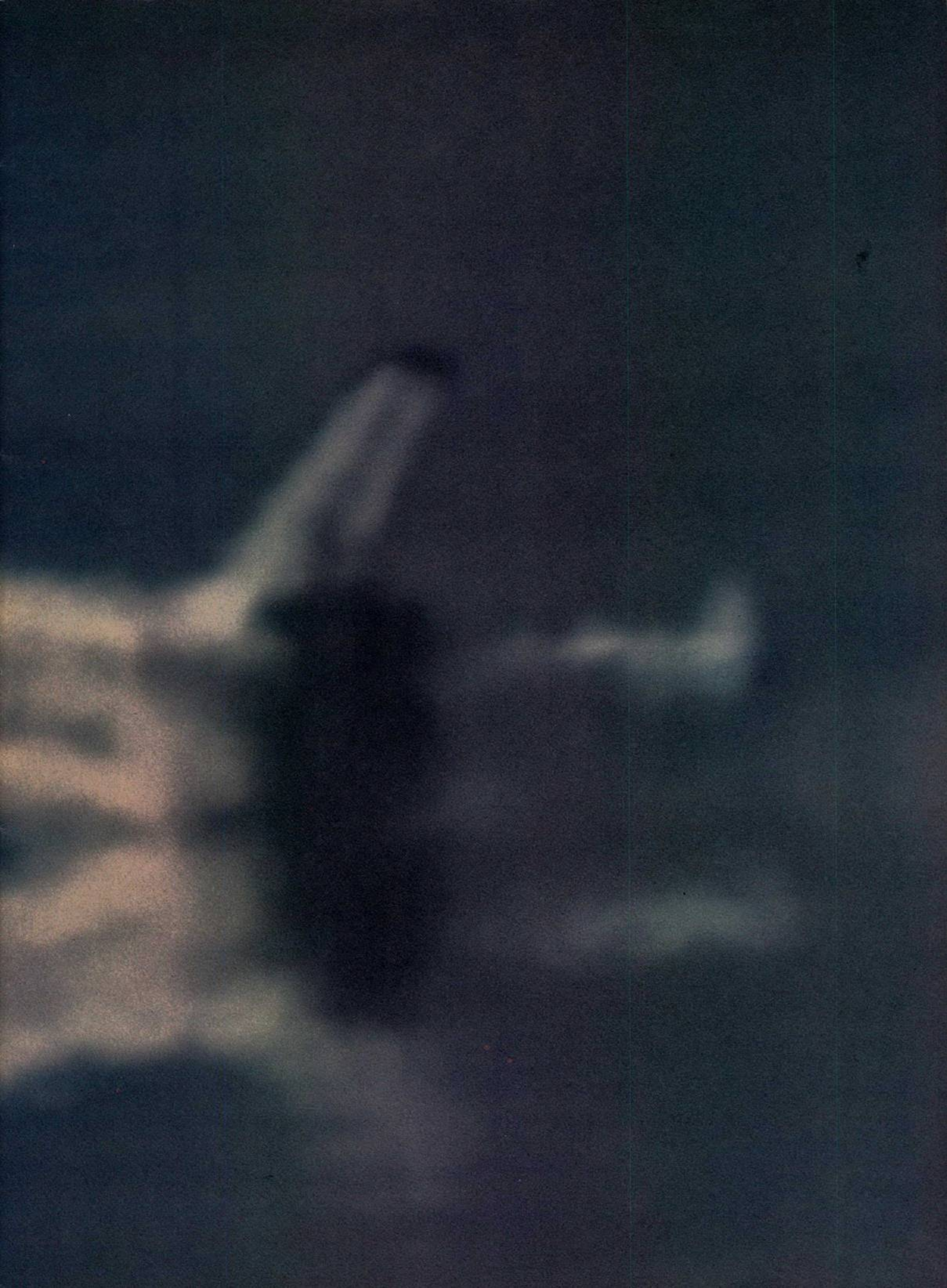
The Space Shuttle is the most complex, most sophisticated, most advanced machine ever created by man. But it is more than the sum of its technological parts: it demonstrates American

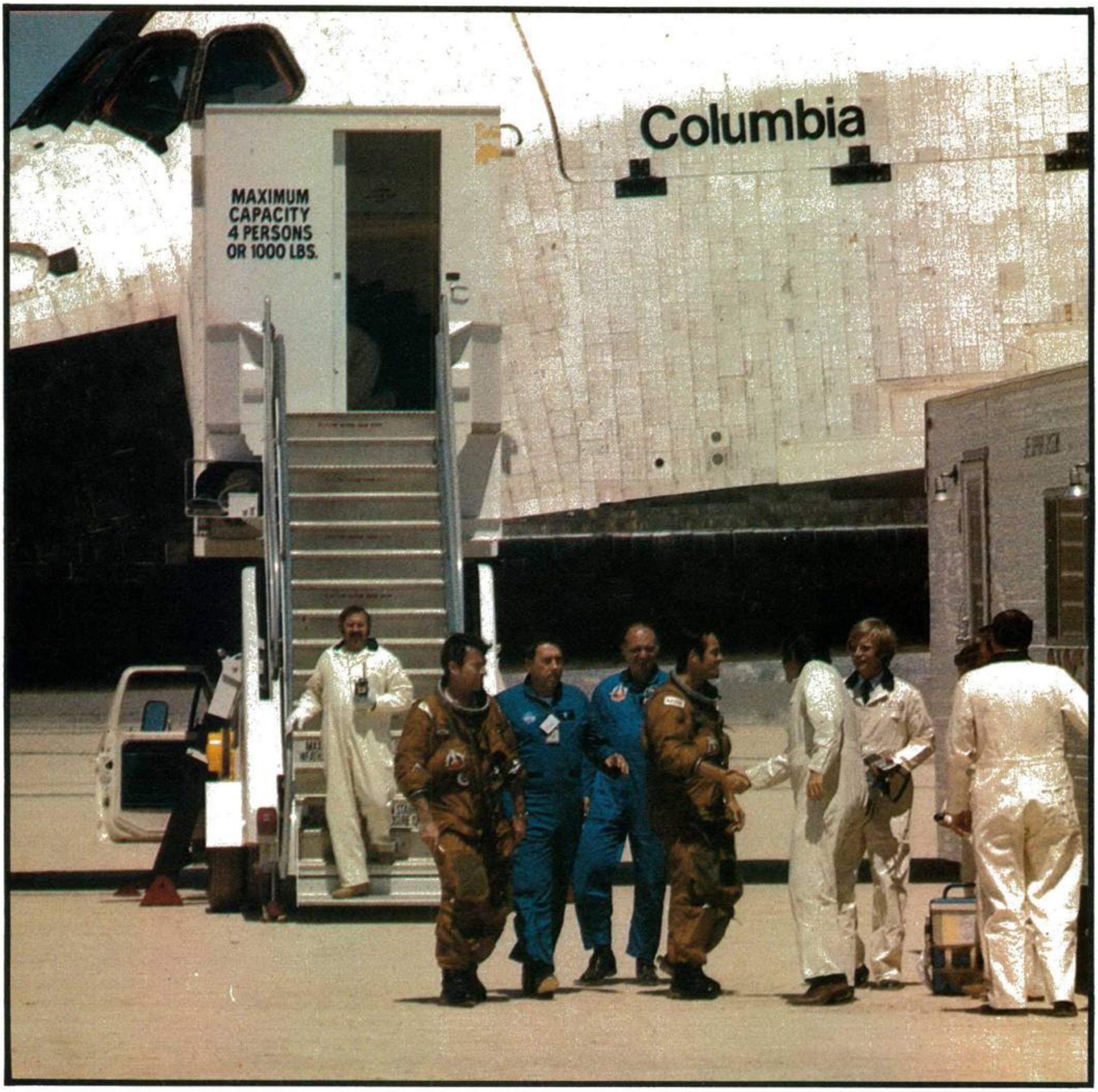
Completing its final turns before landing, the Shuttle is joined by chase planes that monitor its descent. Inset taken by Dick Rucker; large photograph, taken from a chase plane, courtesy of NASA.

NASA
United States
Columbia

Touchdown! Fifty-four orbits after liftoff, *Columbia* touches Earth again on Rogers Drylake Runway 23 at NASA's Dryden Flight Research Center, Edwards Air Force Base, California. Photograph by Jeff Schroeder with a 1000mm telephoto lens. Heated air over the dry lake caused the image distortions.







Astronauts Young and Crippen (gold color suits) leave *Columbia*, receiving congratulations for a successful mission. The Shuttle itself received very little damage in its flight and atmospheric re-entry — so little that only 100 tiles need to be replaced. The next flight, STS-2, has been advanced two weeks. NASA photo.

achievement to the world. It has shown Americans can still be first and best. With the successful launch of the Shuttle, the United States space program has become a space program for the whole of humanity.

Still, some people don't understand the euphoria over the launch of the Shuttle. Perhaps it has something to do with heroes and goals, with dedication and inventiveness, or with our hopes for our future and the future of our children, and for their children, too.

According to some experts, our planet, our spaceship Earth, can support about three billion people indefinitely. But right now, mankind is approaching four billion, depleting the resources of the planet. If the Space Shuttle does no more than continue to remind humanity that we must treat our tiny planet with care, it will be worth all the dollars we spend on it.

But if it can help us look out from our planet to learn and expand, it may repay us thousands of times over. Humanity cannot avoid the future: we will be part of it whether we can cope with it or not. If the Space Shuttle keeps us pushing to reach out beyond ourselves, we may manage to solve the problems we'll face.

Michael Boelke, an industrial artist, has been a student of the space program and an amateur astronomer for many years. His artwork has appeared in previous issues of ASTRONOMY.

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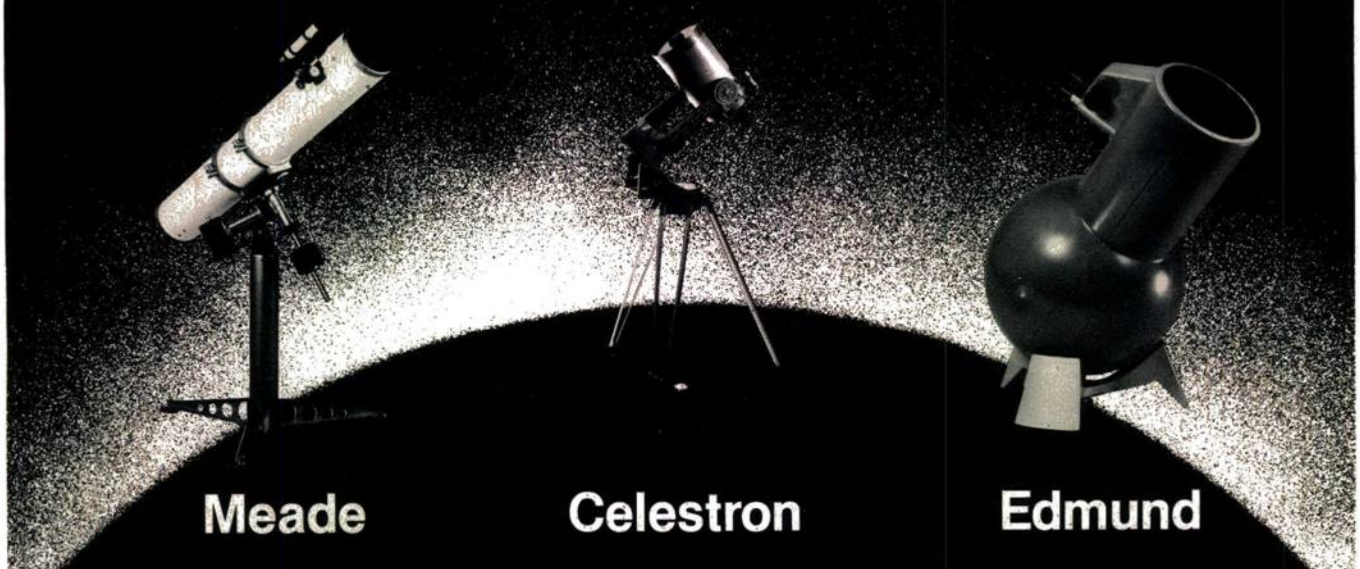

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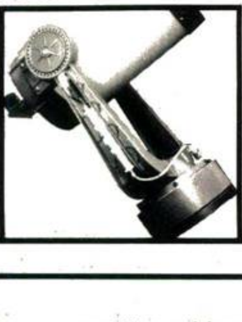

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ASTRONOMY
FORUM

Ain't We A Wonderful Species

And we beheld what no human eyes before ours had ever seen.

The world outside was strictly alien. Heavy fog had been slithering across Southern California for two days. A seventy-car daisy chain crackup on the Golden State Freeway had killed seven people the night before. Creeping through the hills past La Canada-Flintridge, it was a scene Chesley Bonestell might have painted thirty years ago to illustrate an extrapolative article about the surface of Titan.

The time for patience with artists' renditions was at an end: I was on my way to see the actual surface of Titan. What no human eyes had ever beheld.

Tuesday, November 11th, 1980. The Jet Propulsion Laboratory in Pasadena. NASA's Voyager I was on its way to closest approach with Saturn; with Titan and Tethys; with Mimas and Enceladus and Dione; with Rhea and Hyperion and Iapetus.

In the Von Karman center, where the press hordes had begun clogging up since 7 a.m., it was hurly-burly and business as usual. The women in the mission photo room were several decibels above hysterical: nothing but hands reaching in over the open top of the Dutch door demanding photo packets.

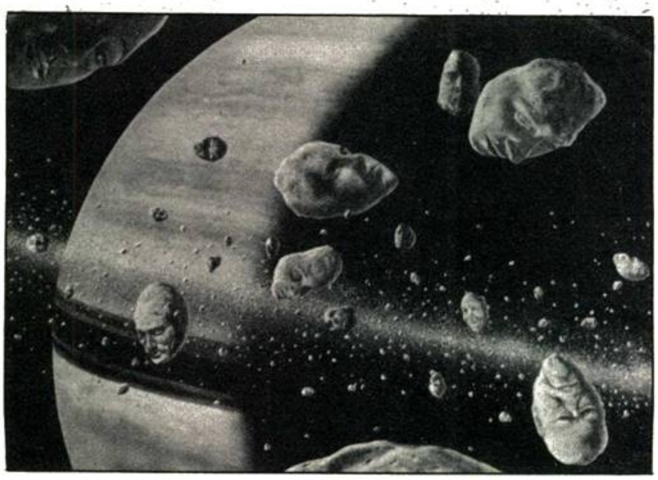
The press room was chockablock with science editors and stringers and lay reporters fighting to use the Hermes manuals lined up six deep. They were all there: the guys from *Science News* and *Omni*, the women from *Scientific American* and *Time*; heavyweight writers and their own word processers and Japanese correspondents festooned with cameras; ABC and NBC and CBS and Reuters and the AP. The stench of territorial imperative hangs thick in the crowd. I slip behind an empty typewriter and begin writing this column. An enormous shadow blocks my light. I look up over my shoulder at He Who Looms. "That's my typewriter," he says, of a machine placed there by JPL. What he means is that he got to it a little earlier than anyone else and has squatter's rights, as opposed to a sharing configuration. I smile. "Need it right now? Or can I have about ten minutes to get some thoughts down?" He doesn't smile. "I'm Mutual Radio," he says; in his umbrage that is surely explanation enough. My eyes widen with wonder. "Are you indeed? I always wondered what Mutual Radio looked like. And a nice job they did when they turned you out." I pull the paper out of the Hermes and vow tomorrow I'll schlep my own machine in.

They were standing in line at the coffee urns.

Everyone looked important.

Everyone was watching to make sure no latest photo slipped past. And the JPL press liaisons were hiding the nifty Saturn buttons.

And everywhere the talk was of the mysterious "spokes" radiating out across Saturn's rings, of the ninety-plus ring discovery, of the inexplicable darkness covering



"Souls of Saturn," painting by Michael Carroll

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Titan's northern hemisphere.

In the course of human events, far fewer are real than we are led to believe. The staged press conference, the artificial happenings, the protesting crowds that wander somnolently until the television cameras turn on them and they begin chanting, waving their fists. Planned, choreographed, manipulated — to make us believe great things are going down. But they are not. It is sound, it is fury, and as usual it signifies nothing. But occasionally there are genuine moments during which history is being made.

This was written by one of *The New Yorker*'s unsigned editorial hands a number of years ago:

This is notoriously a time of crises, most of them false. A crisis is a turning point, and the affairs of the world don't turn as radically or as often as the daily newspapers would have us believe. Every so often, though, we're stopped dead by a crisis that we recognize at once as the genuine article; we recognize it not by its size (false crises can be made to look as big as real ones) but because in the course of it, for a measurable, anguished period — sometimes only minutes, sometimes hours, rarely as much as a day — nothing happens. Truly nothing. It is the moment of stasis between a deed that has been performed and must be responded to and the deed that will respond to it. At a false turning point, we nearly always know, within limits, what will happen next; at a true turning point, we not only know nothing, we know (something much more extra-ordinary and more terrifying) that nobody knows. Truly nobody.

There are times when the world collectively holds its breath. The assassination of John Kennedy, the Cuban Missile Crisis, the day the Viet Nam War ended, the Manson family murders, the Hungarian uprising in November 1956, Pearl Harbor, Hiroshima and Nagasaki. Real things were happening, the world was changing; the breath paused in our bodies.

And this is one of these timeless moments. Something real, something urgent, something is happening.

The human race is fumbling toward the light through outer darkness; and there is a feeling here of movement, of genuine wonder. The sense of isolation dissipates.

The press briefing is held half an hour earlier than expected and the room is jammed to the walls. A full-size replica of the Voyager bird dominates the left side of the briefing auditorium. The television networks have their martian war-machine cameras ranged across the rear of the seating area behind the press representatives from major news outlets and, seemingly, from every Podunk Gazette in the country. Snatches of conversation in French, German, Japanese. The planet Earth is gathered here to know!

The recap of the previous day's findings leave mouths gaping. They have discovered something on Tethys. Is it a crater? No, the albedo indicates it's a hill. The NASA spokesman calls it "a heck of a hill" — hundreds of kilometers across. But only time and greater resolution of the photographs will tell.

Brad Smith, leader of the imaging science team, cannot conceal his amazement as he reports that at least two eccentric rings have been found in the mass of circulars casting their shadow on Saturn's cloud-masses. He says they had no reason to expect such a thing, that it defies all the known laws of ring mechanics. What he doesn't say is that if every Bible Belt fundamentalist who believes we never actually went to the Moon, that we flew over to Glendale and shot all that stuff in a movie studio, could be here, to see what these people are doing, what is being sent back minute by minute over a distance of 930,000,000 miles, they might begin to understand that God was too busy creating esthetics to worry about putting the solar system together.

"The planet Earth is gathered here to know!"

It is all so complex, so bewilderingly intricate, even the best minds in the room are finding it difficult to keep up with the new discoveries:

The rings, for instance.

A constant revelation. They simply don't know what keeps the rings separated. General knowledge, since the Dutch mathematician Christiaan Huygens discovered the true shape of the rings in 1659, has contended that — at most — there were five. (The state of our knowledge, and the breakneck acceleration in what we've learned, is expressed in this absolutely latest-thinking from *The World We Live In* (1955) edited not only by the staff of *Life* magazine, but by the renowned author of *The Universe and Dr. Einstein*, Lincoln Barnett: "Although Saturn's three concentric rings rotate in a circle 171,000 miles across, they are only a few inches thick. The middle ring, largest and brightest of the three, is 16,000 miles wide and separated from the outer by a 2000-mile gap." That latest-state-of-the-art in 1955 was a caption accompanying a Chesley Bonestell painting of Saturn's three rings.)

As of this November 18th the Voyager team has isolated almost 1000 rings; and the estimates go as high as 10,000. The rings have rings; the ring's rings have rings; and the ring's rings have ringlets.

But what keeps them separated...?

The *NASA News* backgrounder on the mission, dated just October 28th, says this: "At least six rings surround Saturn. From the planet outward they are designated D, C, B, A, F and E. Divisions between the rings are believed to be caused by the three innermost satellites, Mimas, Enceladus and Tethys. The Cassini Division, a space between the B and the A ring, is the only division clearly visible with a small telescope from Earth."

But here it is less than two weeks later and we sit in the morning briefing and hear that the Cassini Division is anything but empty. Rings within rings within rings. And tiny satellites, acting as "sheepdogs" (Jerry Pournelle's wonderful term for them), seem to be holding rings apart, seem to be serving as outriders in this complex, astounding system of cosmic detritus.

Science fiction writer Greg Bear asks Smith if he has any random guesses as to how old the rings are, how stable they are, and how long they'll stay in this wonderful sequence. We expect another humorous "well, I can't really say for sure" response, but Smith replies with force, "They're four and a half billion years old, they're very stable, and they'll be there till the Sun enters its red giant phase." Everyone is impressed.

No one can even begin to grasp what four and a half billion years means in terms of waiting time at the airport, but it is clearly longer than next Thursday at 4:15 p.m.

Humanity is only 1.3 billion miles from the surface of Titan, and one of the members of the press corps asks a dumb question. He didn't realize the NASA spokesman was making a subtle joke. An ingroup astronomical joke. His question is answered politely, but everyone in the room thanks God it was not s/he who had asked the dumb question. To look like a schmuck in the same room where Clyde Tombaugh, discoverer of Pluto, sits listening, is to put oneself forever beyond the pale. Five minutes later someone else asks a question to which the response is, "That's a very good question, a very important question," and He Who

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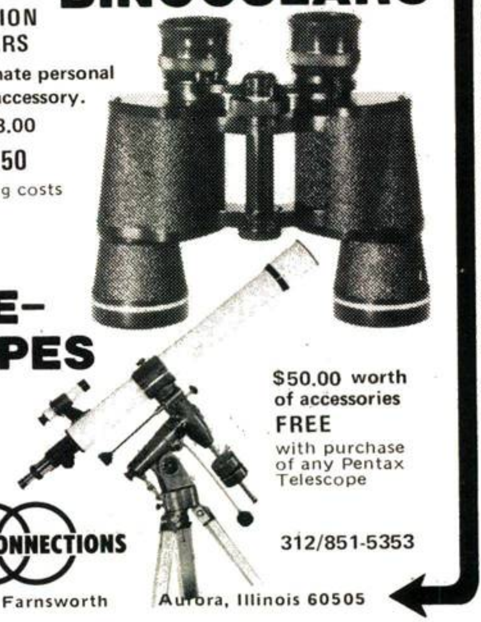

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Dear Mr. Nagler,

This last day of 1980 is the first day of a whole new era of enjoyment of my telescope for me — thanks to your new Plössl eyepieces.

Last night I got my first chance to compare your TELE VUE Plössls (26mm, 17mm, and 10.4mm) to my XXXX and XXXX. I found the TELE VUE eyepieces to be superior in every respect: wider and flatter field, sharper star images to the edge, better eye relief, and vastly higher contrast. This last item really surprised me. The night was murky with wood smoke particulates from the suburbs as well as with the usual haze and pollution common to the Washington, D.C. area — not really a good night at all — but around here, "ya takes what ya gets". For an hour, I compared your 26mm Plössl to my 24mm XXXX. I had always considered the XXXX unbeatable for sharpness and image contrast, but the TELE VUE was far better! For example, on M42, more outer wreath nebulosity stood out against the (bright) sky background than with the XXX plus a nebula filter! In the trapezium group, two of the dim field stars (stars E and F in Mallas and Kreimer, the Messier Album, P. 99) were easily seen using the TELE VUE eyepiece but were invisible through the XXX even though its slightly shorter f.l. should have made them even easier to see. This observation was confirmed by another person working with me.

As you can see from the attached list of eyepieces that I have owned over the last 5 years and now own, I have rejected more than I've kept (this includes one 2-inch $200 eyepiece that many experts had said was the very best available). I can tell you with assurance that my new TELE VUE Plössls will never appear on my list of rejected eyepieces!

You have my admiration and sincerely felt thanks for bringing such quality to the American amateur astronomer.

Yours most sincerely

Pat Walker
Springfield, VA

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Asked could, at that moment, be elected President of the World.

I am an eyewitness to history, and I make a mental note to thank Jerry Pournelle for getting me VIP credentials; I am far out of my depth, but I am at the eye of the hurricane and I owe thanks to Jerry.

Slides from images sent back by the Voyager are flashed on the screen. Photos of the Cassini Division separating the A and B rings. The scientists admit that traditional celestial mechanics cannot account for the phenomenon of their eternal separation from one another. Not even the "sheepdog" satellites can be adequately explained, the way they work, the way they push up and pull down the ice particles, speed them up and slow them down, keep them circling in their intricate cosmic pavane.

But they seem to revel in their lack of explanations. They suppose this, and they postulate that, and they are like kids who have been given a glimpse of a new toy with which they can play for years to come. It is the best part of this extraordinary game that has thrown four hundred million dollars worth of Voyager 1 and 2 tinkertoy into eternal darkness. It is the most salutary part of the rigorously analytical intelligence: it loves to have been fooled, it loves to be surprised.

They realize they have made pronouncements of What the Laws of the Universe Are and are being proved wrong minute-by-minute. But they don't defend what they said in error; they admit, they recant, they rush to say no, here's what it is now, and here's what it looks like now, and look at *that*, and look at *that*! One can only love them for it.

They talk a great deal about seeing what's coming in with "terrestrial eyes" and with "jovian eyes." What they mean is that we are too ethnocentric, that when Voyager 2 made its encounter with Jupiter sixteen months ago, they interpreted what was relayed back through eyes and intellects chained to a Terran horizon for millions of years. Now, with bemused embarrassment, they admit to early misinterpretations of visual data because everything was viewed as if it were of the Earth...out there. But Ganymede brought important lessons about seeing with new eyes. Yet it's happening again — with the difference that "ganymedian eyes" are being added to the viewing of the Saturn system. Nonetheless, how miraculous: seeing with the eyes of aliens. Knowing that what is revealed is only partially real, that much of the "reality" is merely shadow, as seen through human organs not yet completely retooled for new vistas.

These are human beings transcending their limitations, going to a new realm of perception not through the duplicity of drugs and fuzzy sophomoric metaphysics that demand the purity of Zen rigors, but through confrontation with the pragmatic universe, through hard analysis of the laws of that physical universe, no matter how anomalous and labrinthine they may be.

Angie Dickinson appears in the briefing auditorium and the PIO nabobs begin whirling like dervishes. She is there strictly as an "interested bystander" I'm told, but she gets more attention than Clyde Tombaugh. I sigh deeply.

Voyager has discovered (three) new satellites: S-13, S-14 and S-15. And they have "undiscovered" one that has been there since 1966.

Quote from the current edition of *The World Almanac and Book of Facts*, 1980 (page 761):

Saturn has 10 satellites, the 10th having been announced by the French astronomer, Audouin Dollfus, in Dec. 1966. The new satellite is a few thousand miles outside Saturn's ring system, but it is so faint that there is some doubt as to its existence.

"they are like kids who have been given a glimpse of a new toy..."

Quick thinking, *World Almanac*! Dollfus's tenth satellite, which he called Janus after the two-faced Roman deity, does not exist. Poor Dollfus. It simply ain't there. Every science fiction story using Janus as its locale is now down the chute. (I gloat. I am not a science fiction writer, no matter how my work is mislabeled by anal-retentive pigeonholers; I have written so few stories that required a scientific education that I have nothing to apologize for. I feel sorry for Hal Clement and Isaac and Poul and Larry Niven. Only Andre Norton can get away with it: her *Judgment on Janus* was written in 1963, before Dollfus' gaffe, and she made her Janus an alien world in another star-system.)

The bird makes its closest approach to Titan, largest satellite in the solar system and the only one with a discernible atmosphere, at 9:41:12:12 Tuesday night and the final hope that a view through to the naked surface will be possible...vanishes. One of the scientists, who bet a case of cognac that a peep would be possible, loses the wager. And we all lose. Titan is covered with smog. Clouds of liquid nitrogen vapor, but maybe the atmosphere isn't a nitrogen mixture. Hydrogen cyanide is discovered; there may be an ocean of liquid nitrogen down there; if such an ocean exists, the methane icebergs would sink to the bottom.

Much of the human race would not spend four dollars to journey to Los Angeles, blanketed by photochemical smog; but the species *in toto* has traveled one and a half *billion* miles to visit a place with even worse smog.

And on the evening news as I drive home, talk of the Saturn flyby appears at the bottom of the broadcast. Top spot dwells on the war between Iran and Iraq.

I sigh deeply.

Wednesday the 12th of November, 1980. The 10:30 a.m. briefing on the day of the main events:

2:16 p.m. Closest approach to Tethys (258,000 miles).

3:45 p.m. Closest approach to Saturn (77,174 miles above clouds).

3:48 p.m. Six photos of the new satellite, S-11.

5:42 p.m. Closest approach to Mimas (55,168 miles).

5:50 p.m. Closest approach to Enceladus (125,840 miles); Enceladus' radius is 260 kilometers, 162 miles; Earth receive time of the images: 7:15 p.m.

7:39 p.m. Closest approach to Dione (100,122 miles).

9:45 p.m. Voyager crosses the ring plane on its outbound leg.

10:21 p.m. Closest approach to Rhea (44,744 miles); Rhea's radius is 750 kilometers, 466 miles.

A quick and infallible test of the imagination quotient of your friends and lovers. Tell them we're looking at a new world, Rhea. If s/he says, "So what?" or "What good is that?" ask for your ring back and walk away fast.

The briefing is even more jammed than yesterday's. I sit with Dick Hoagland so he can explain everything to me. I need to know what albedo means. I'm sure he'll be tickled to explain the ABC's of celestial mechanics to a no-neck scientific illiterate. (At least I don't have to arm-wrestle Mutual Radio for a typewriter. I've brought my own Olympia portable — the one with the Mickey Mouse decal on the case — and I snag a desk formerly occupied by Peter Schroeder of Dutch television and radio. It's a good thing I got there early: Tuesday's smash&grab for mission photos and space to bat out news copy has intensified. One yahoo caught rustling a CBS word processor is lynched before our

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Opening remarks by Voyager Project Manager for JPL, Ray Heacock, reinforces the sense of wonder. They have been incredibly lucky overnight. During the Titan-Earth occultation period — 11:12 to 11:24 p.m. — there has been rain at tracking station 63 in Spain. It started and stopped during a time when, had the spacecraft not been measuring atmospheric properties as the radio signal continued to fade, we would have lost masses of valuable data. But it didn't matter during occultation.

More wonder: Heacock says, with an impish grin, that they made an error in timing: because they didn't know precisely where Titan would be (or something like that), the Voyager made the ring plane crossing 49 seconds earlier than expected. Everyone laughs. The bird has been in transit for three years and the biggest miscalculation is 49 seconds. The next time I call the telephone company about a repair and they tell me it can't be done, I will tell them anything can be done.

I smile with pride at my lovely species. We ain't so goddamn dumb after all.

(Middle of the day Tuesday, a slow time with everybody out to lunch, I went to the astonishing botanical gardens of the Huntington Museum with Jane Mackenzie and Bob Silverberg. We wandered through alien terrain straight out of a 1936 Frank R. Paul cover from *Amazing Stories*, a desert garden of a million kinds of seemingly extraterrestrial cacti. And Bob ruminated. "I was standing next to one of those scientists at the back of the auditorium during briefing," he said, "when he was describing something incredibly arcane; and I looked at him. I was looking at something like 180 I.Q. and I knew that man was smarter than I. Far smarter. And I'm smart.")

The briefing goes on. Norman Ness, from the Goddard Space Flight Center, principal investigator on the magnetic field team, explains how the Voyager passed through Saturn's bow shock wave at 4:50 p.m. when Titan was inside the magnetic field envelope of the planet. He speaks of the solar wind, the flow of ionized gas given off by the Sun that hisses through the solar system. There is no poetry in the words...only in the way he speaks of it. Norman Ness barely realizes he has looked on the face of the Almighty.

The photos we're seeing are four times as detailed as what came in over the TV screens real-time. Television's scanning pattern permits only one-quarter of the information contained in the photos sent by the Voyager's imaging systems to reveal itself when we see it on the screen. Even so, the details are remarkable.

But most remarkable of all is the revelation that three components of the F ring seem to defy the laws of pure orbital mechanics: they are braided. Such a thing cannot be, yet we look at the photographs and we see that indeed, the rings do twine. Brad Smith of the University of Arizona is totally at a loss to explain it. He cannot even make a joke. He looks like a man stunned by the hammer. He says that of all the improbables he might have postulated, even to the inclusion of eccentric rings, which have now been verified, the braiding is so far off the wall he could not even have conceived of it.

We stare at the pictures.

The rings twine around each other. The room falls silent for a moment, we hold our breath; we are living in one of those special moments when *something is happening*, something important.

The celestial engineer has been cutting capers again.

A photo of Mimas taken at 5:05 a.m. Pacific Standard Time from a range of approximately 400,000 miles shows an impact crater 80 miles in diameter. It shows a rebound peak God only knows how high in the center of structure. The crater is more than a quarter of the diameter of the whole damned iceball. It may be the largest impact crater, relative to the size of the object struck, in the solar system. What will the shock pattern on the other side of Mimas look like? What will it tell us about how big a projectile can be before it blows something like our Moon to smithereens?

"we are living in one of those special moments when something is happening, something important"

That's why you asked for your ring back and walked away fast when the feep didn't understand.

During the press conference — between 10:53 and 10:56 a.m. — the mechanism making search-sweeps for new satellites apparently discovered S-16. Later it turns out to be S-10.

Patrick Moore, he who knows more about our Moon than anyone else writing about Luna, asks Smith about a small satellite that might be controlling the inside boundary of the C ring. Smith gets an expression that is the equivalent of crossing one's fingers and responds that he hopes it's there...because if it's there it will go a long way to explaining how the rings hold together. He says they will modify the Voyager 2 search patterns to locate it...if it's there.

It becomes clear that the photos we're being given for publication are merely bullshit PR. That as soon as this circus leaves town the scientists upstairs can employ full computer time to analyze the pictures instead of putting together "pretty pictures" for the press.

And that's exactly what happens.

Within two days, they have analyzed so much of the material that they've revealed a wind on the surface of Saturn that blows at 1100 miles per hour. If that wind were here on Earth it would be blowing in a steady line from Philadelphia to Buenos Aires.

And then comes the explanation for the anomalous "spokes" that were seen radiating out through the rings. It is an explanation so unbelievable that it can only be termed a *Star Wars* special effect.

As the Voyager fell through the ring plane on the 12th, heading for its closest encounter with Saturn, a secondary experiment on board — "The Planetary Radio-Astronomy Receiver" — picked up enormous bursts of energy — static — identical to terrestrial thunderstorm noises... but a million times stronger than anything in the solar system.

The bursts of energy coincided with the mysterious "spokes" seen in the rings.

Putting the results together, the Voyager team has tentatively come up with an awesome mechanism operating within the ring, namely, electrical discharges — lightning — occurring over tens of thousands of kilometers.

The Voyager was literally being shot at by Saturn as it flew past. The "spokes" seem to be — hold your breath — enormous linear particle accelerators!

As best I can explain it to you (and most of this comes from Dick Hoagland), here's what causes this phenomenon that cannot be explained within the parameters of known celestial mechanics.

The density of material in the B, or center, ring is the highest. The highest number of, literally, icebergs per cubic mile. Because of the inevitability of Keplerian mechanics, the bergs closest to Saturn are orbiting faster. Any ice object with an eccentric orbit, even a few meters of eccentricity, will collide with other bergs. Because of the brittleness and cold of this ice they naturally fracture producing, well, producing chips off the old block. Then those fragments collide and

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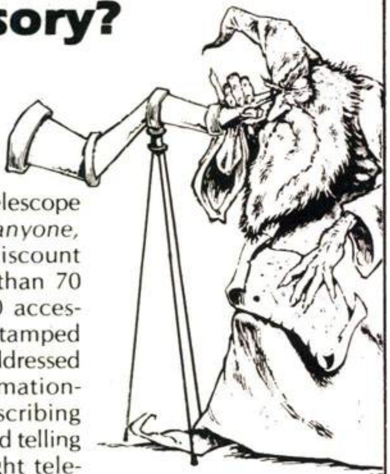

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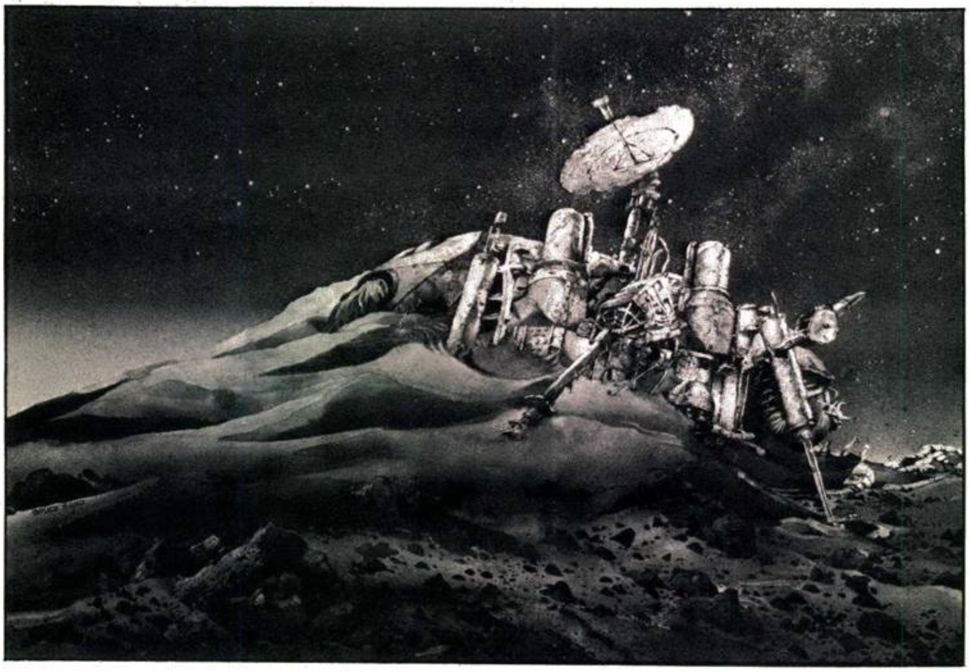

Viking at Mars... 500,000 A.D.

Its instruments dead, the men and women who built it forgotten, the blind and pitted hulk of Viking 1 — once a tribute to mankind's technology and pioneer spirit — stands as a lonely memorial to humanity's flirtation with planetary exploration.

This poster is made from the original painting used to illustrate "Mars 5 Years after" in the July 1981 issue of ASTRONOMY.

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chip again and again, getting smaller and smaller. These collisions continue in a never-ending rubble-producing process.

But. When this occurs in Saturn's two-hour shadow, when the fragments sail out into sunlight the smallest particles — micron-size, perhaps — are charged up by interaction with solar ultraviolet light and, because like charges repel as any dummy clearly knows, they literally try to get away from the rings. Producing a levitating cloud of charged ice crystals elevated above the average ring plane who knows how far...several miles to several *thousand* miles.

Grabbed by Saturn's magnetic field (magnetic fields and electrical charges, Hoagland assures me, go hand-in-hand), they are lined up in a linear feature tens of thousands of kilometers long, stretching from the outer edge of B ring in toward Saturn. Straight and narrow as a flashlight beam. These appear in the optical images as "spokes" which rotate anomalously around the planet defying all explanation. At this moment.

Give them a week more.

And so these electrified ice crystals apparently discharge along the length of the spoke creating, in effect, the solar system's largest radio antenna as well as a natural linear particle accelerator.

Even I, scientific illiterate, aware of the breakthroughs in particle physics that have come from such terrestrial plants as the Batavia, Illinois proton synchrotron, can extrapolate what it would mean to harness that "spoke" mechanism to aid us in discovering precisely of what matter is composed, how it works, how it came to be.

Explain that to the feep who said, "So what?"

I overload. I cannot contain any more new information. I pack it in and lie down and turn on the radio.

The news is all taken up with how high the stock market has jumped with Reagan's latest fiscal pronouncements. And the war between Iraq and Iran. I close my eyes and slap the button off on the radio.

I sigh deeply. Ain't we a wonderful species.

Harlan Ellison
Sherman Oaks, California

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PROBLICOM in Action: The Search for Novae

Since August 1977, I've been actively searching for novae and comets. Yet I haven't spent a lot of money or bought any fancy or complicated equipment — mostly I've invested my own time. I'm a member of the PROBLICOM nova patrol program — an organized group that watches sectors of the celestial sphere for evidence of novae — that is co-ordinated by Ben Mayer of Los Angeles (see "Blink for a Nova," ASTRONOMY, May 1978).

The method is simple: I take short exposure sky photographs with a 35mm camera at different times. Then I "blink" the pictures with my home-build PROjection BLInk COMparator. I have logged hundreds of exposures totaling dozens of hours of exposure time and searched an enormous area of sky.

The search has gone unrewarded only in one sense: that no PROBLICOM blinker has yet found one of the elusive novae in a patrol photo. My reward, and a substantial one at that, has been a growing number of slides that show our universe in action.

Recently my patrol slides of the region around Regulus have yielded two planetary "supernovae" — as Mars and Jupiter moved slowly through the field. And, in the patrol region around Alpha Librae, Uranus slips back and forth as it retrogrades and gives the impression of a bright asteroid on its lonely journey through space. Some of the patrol slides have shown the path of tumbling earth satellites leaving a "dot dash" signature as they pass by during an exposure. Although they were not photographed in my patrol area, I saw the last orbits of the late Skylab as it passed over during one of my vigils.

PROBLICOM blinkers are assigned targets separated by six hours of Right Ascension. For each season, there is a target or two in good position. If I get up a couple of hours before dawn, I can shoot areas that are technically two seasons. ahead!

There is something special about these early moning sessions. They are, for me, the most quiet and relaxing and they provide a gentle perspective on my place in the universe.

At these times, when I look up from the guiding eyepiece, I see a good number of bright meteors. Even though they never seem to pass — be it Murphy's Law or whatever — through the camera field, they are a beautiful sight and help focus the wandering thoughts that come to the solitary observer.

Since I blink at least twice a month, I have become more conscious of the sky and its occasionally dramatic displays. Two spectacular aurorae have surprised me during blinking sessions. One, exceptionally intense, produced flashes of light at the zenith as though it were a celestial neon sign.

On at least two separate occasions, I've seen and photographed the zodiacal light in the pre-dawn sky. The situation was similar to textbook conditons: the sky was dark, and many city lights had been off since midnight. While patrolling Leo, I noticed a cone of light in the east. It was wide at the horizon and tapered slowly toward the zenith. Since I hadn't seen the zodiacal light before, I wasn't sure that I might not be seeing dawn's first light. I quickly photographed it, then later confirmed that true dawn began some thirty minutes after the exposure!

I've learned about variable stars, too. Variables blink on and off in imitation of novae. Chi Cygni, for example, drops below my camera's threshold when it's at its 14th magnitude minimum, but I've seen it glow ruby red at its 3rd magnitude maximum almost a year later.

Asteroids passing through the patrol area always cause a certain amount of excitement when first "discovered." Each one must be checked with a photo the next night — hopefully to be identified by its motion. The charts supplied by Jay U. Gunter in his bimonthly newsletter *Tonight's Asteroids* are a big help. This past autumn, I enjoyed watching Juno perform its retrograde loop near the bright star Procyon. Similar loops have been taken by the 10th magnitude asteroids Metis and Amphitrite near Epsilon Leo.

Perhaps the single most important personal gain I've enjoyed as a PROBLICOM participant is friendship. People that I've come to know through it share my astronomical interest and dedication. During the 1979 Stellafane Convention in Vermont, no less than 13 blinkers were present.

It isn't a cash prize for a discovery that brings me out into the New England winter armed with camera and guide scope. The real prizes are the novae yet to be found and the numerous other "intruders" that pop up unexpectedly. For this alone, the PROBLICOM program is already a tremendous success.

Phil Dombrowski
Glastonbury, CT

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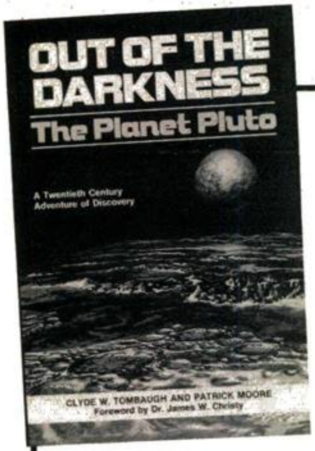
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The Planet Pluto
A Twentieth Century Adventure of Discovery
CLYDE W. TOMBAUGH AND PATRICK MOORE
Foreword by Dr. James W. Christy

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on the
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watch for the meteors!

by
Fred Schaaf

the wanderers

For the past two years, amateur astronomers have enjoyed rare and spectacular "double oppositions," conjunctions and gatherings of planets. The fading of Jupiter and Saturn into the Sun's afterglow next month is the logical end to this period, but August and the early days of September will add an altogether fitting conclusion to this particular cycle of splendor. While Perseid meteors streak in perhaps unprecedentedly great numbers from the northeast, no less than four prominent planets, a bright star and the crescent Moon all converge toward a gathering and tight alignment in the west after sunset.

The **Perseids** have long been considered the consistently best annual meteor shower, producing the highest hourly rates for most observers in most years. As many as 60 to 75 Perseids per hour at best was common for well-placed observers until a few years ago — when the numbers dramatically increased. In recent years, the new heightened peak of the shower, though rather brief, has presented viewers in excellent conditions with rates of 100 and more Perseids per hour.

There is a very strong likelihood that the strengthened activity of the Perseids is associated with the expected return of their parent body, Comet Swift-Tuttle, which could be sighted anytime within the next few years — possibly this year, probably no later than 1984. Swift-Tuttle is the one periodic (relatively short period) comet which is intrinsically even brighter than Comet Halley, but its orbit is such that we have only a moderate chance of it passing close enough to be a bright naked-eye object. On the other hand, there is a remote chance that this object, which had a tail as long as 25° at its one past known appearance (in 1862), could pass close to Earth, in which case it would probably be one of the most impressive comets on record.

But what about its effect on the Perseids? No one can be certain how the shower will behave, but the continuation of the present high rates seems likely, and the possibility of a true meteor "storm" cannot be ruled out. Therefore, this year's shower and the next few (until the comet is long gone) are well worth watching and we should hope that conditions are good. Will they be in 1981?

Among all the factors, the only one which will not be extremely favorable for North American viewers is the situation of the Moon. The Moon is full on the 15th, just three days after the maximum. But the Perseids fall off from maximum much more quickly than they rise to it, so the key nights are perhaps August 10 through 13, and on all these nights there will be at least an hour to observe between moonset and dawn — including the very best hours.

The Perseid radiant (apparent source of the meteors) is in northern Perseus. It is highest around 5:40 a.m. daylight time — about sunrise — and predictions for the astronomical peak (when Earth is actually ploughing through the greatest concentration of meteoroids) are for 1 a.m. and 9 a.m. EDT of August 12. The hours after moonset will be excellent, especially on the big night. In the early hours of August 12, the Moon will go down around 3 a.m. and observers away from city lights and clouds should see in the darkened sky meteors in numbers approaching or possibly even surpassing 100 per hour. The Perseids are swift, bright (averaging 2nd magnitude) and of various colors. Some observers should see fireballs (meteors at least as bright as Venus) and meteors with ionization trails lingering a number of seconds. (Last year I observed a Perseid trail which was visible to the naked eye at least 15 seconds after the meteor was gone.)

Bad weather could wipe out the Perseid shower, but the great grouping of celestial objects in late August and early September will be beautiful on too many nights to be totally clouded out. The only classical planet not involved in the gathering is **Mars**, which is now a dim magnitude +1.8 object rising 2½ to 3½ hours before the Sun. **Mercury** plays a minor role, passing through superior conjunction on August 10, and having an unobservable conjunction (each just 6° from the Sun) with the Beehive cluster (August 5) and Regulus (August 16). By the end of the month, however, Mercury may be visible very low in the sky right after sunset.

But the central members of the gathering will be Venus, Jupiter, Saturn, and the Moon. **Venus** passes near Chi (χ) Leonis (Aug. 4) and Beta (β) Virginis (Aug. 20), but these are minor conjunctions. On the evening of the 25th, -3.4 magnitude Venus will pass 2° south of **Saturn** (shining at 1.2), and on the evening of the 28th is only 53′ south of **Jupiter**, which is then at magnitude -1.3. For about a week around these dates, Venus, Jupiter and Saturn will be within 5° of one another and therefore make a "trio" — a rare event indeed.

The **Moon** will be the other key participant. After having hopscotched from Venus to the close-together Jupiter-Saturn pair at the beginning of August, the Moon will come back at month's end for another conjunction with the three. From about the 23rd to the 28th, Venus forms an extremely compact triangle with Jupiter and Saturn, but by the 29th has moved on enough so that the three are arranged in a beautiful line, left to right in order of decreasing brightness. On the evening of August 30, the young Moon will be located down near Mercury, but the next evening, the last

Lyra was rising in the northeast over the Mojave Desert when John Gibson took its portrait during the great April 12 auroral display. He used a 28 mm wide-angle lens and a 10-second exposure on Ektachrome 400, which was then pushed to 800 ASA. For still more contrast, he then made a duplicate.

in August, it will have risen to join the alignment just to the right of Saturn. Venus, Jupiter, Saturn, and the Moon stand in a glorious line, with about 3° separating each from its neighbor. (Spica, too, is in the line somewhat to the left of Venus.) And from anywhere around 40° N. latitude, this straight line should be parallel with the horizon, with Mercury not far off to the lower right and Arcturus high up, straight above the line.

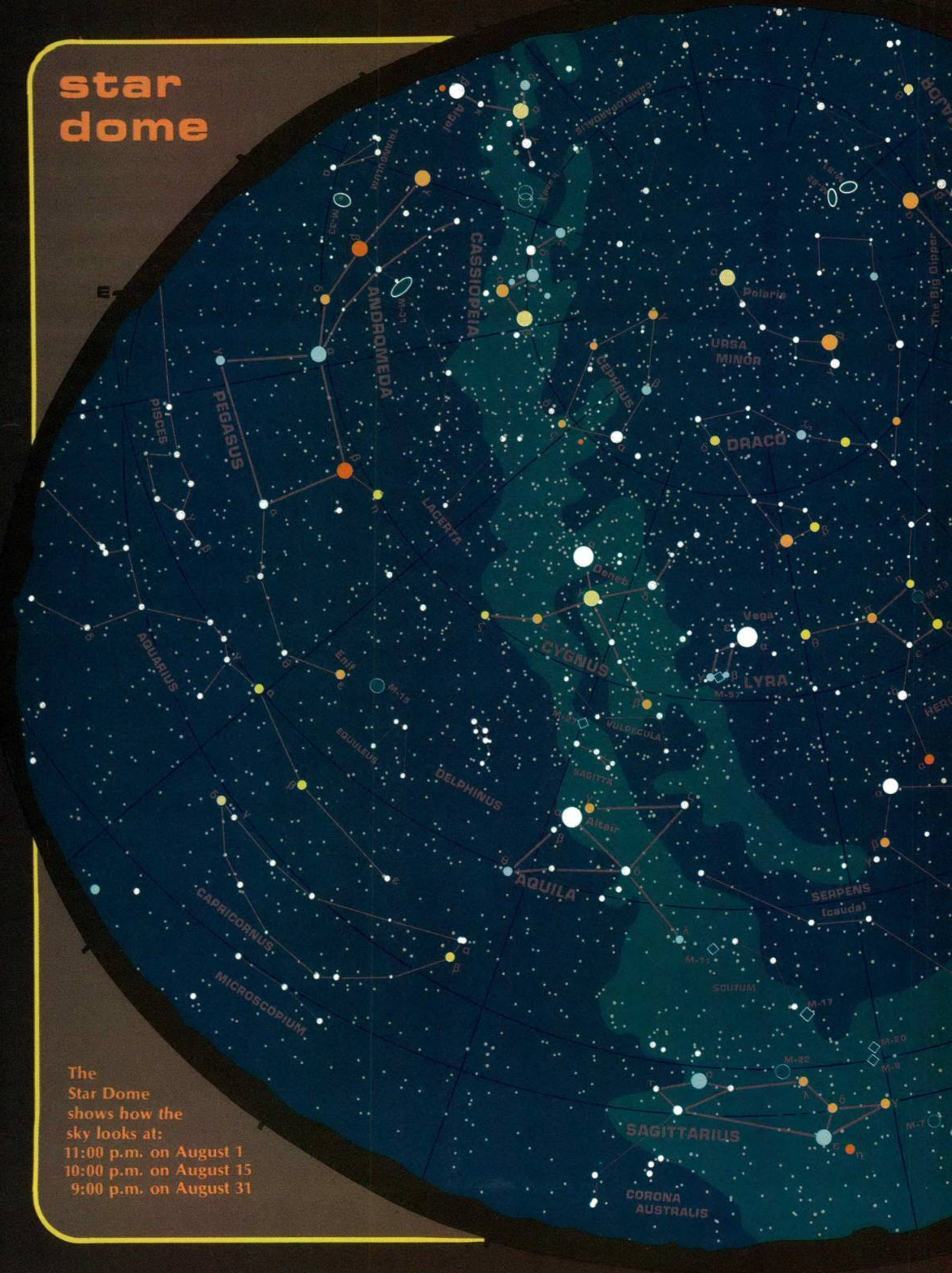
It would be difficult to imagine a more striking arrangement, but even this will not quite be the end. Although the separation between Jupiter and Saturn increases from about 1¼° to 3° during August, the pair will have one last superb get-together in September when they form yet another trio, this time with Mercury — while Venus is near Spica and Mars threatens to invade the Beehive. Stay tuned for details next month.

the starry sky

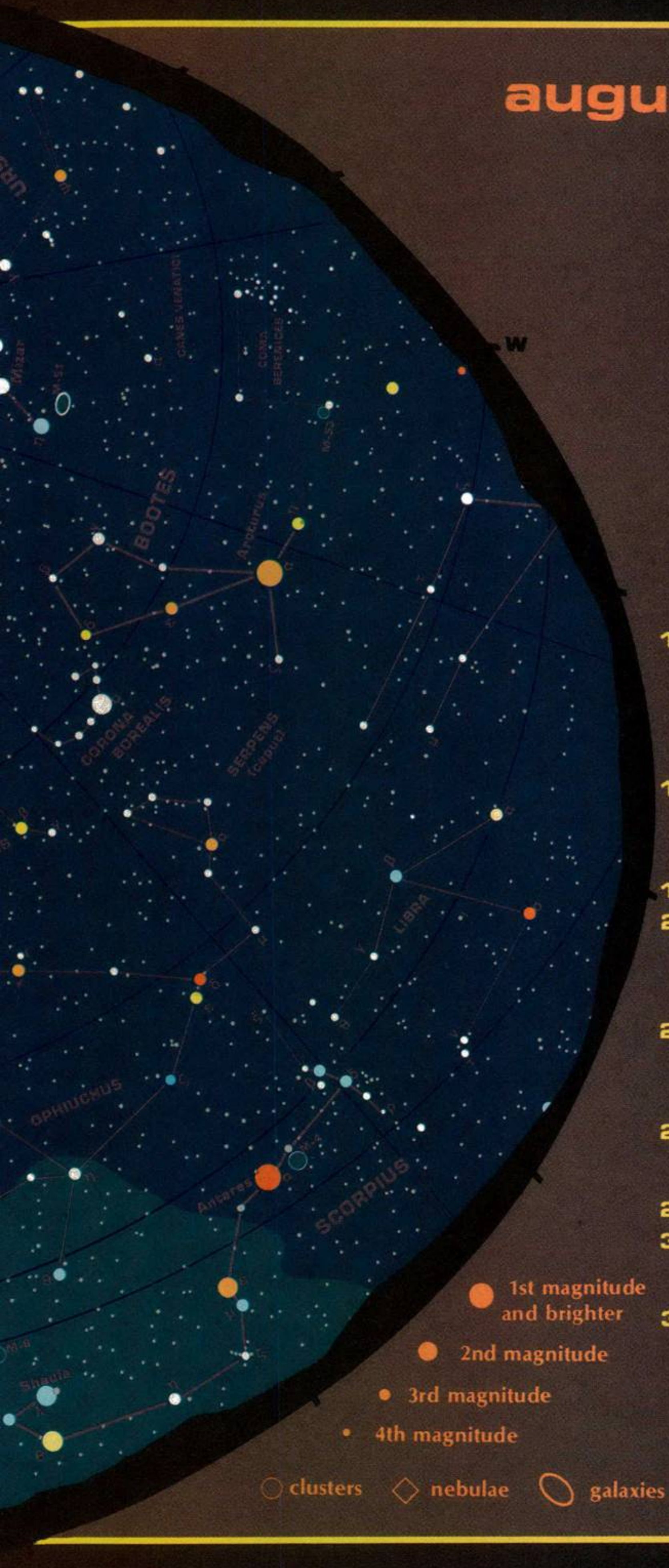
August nights are increasingly long, enjoyably warm, and plentiful with meteors. In the northwest we see the Big Dipper descending and Arcturus still burning bright; in the east we can already see a wave of autumn constellations rising. But, above all (literally and figuratively) there is the sky-arching summer Milky Way at its highest.

As the month begins, it is still high summer — and the queen of summer, just west of the Milky Way, is the star **Vega**. The world's greatest population density clusters roughly along the 40° N parallel of latitude, and for all these people, Vega is the one first magnitude star which passes nearly through the zenith. So when warm weather and the growth of the natural world reach their peak in the northern hemisphere, blue-white Vega,

star dome


Algol
CAMELOPARDALIS
TRIANGULUM
M-33
CASSIOPEIA
ANDROMEDA
M-31
Polaris
URSA MINOR
M-81
M-82
The Big Dipper
CEPHEUS
DRACO
PEGASUS
PISCES
LACERTA
Deneb
CYGNUS
Vega
LYRA
M-57
M-13
AQUARIUS
Enif
M-15
EQUULEUS
DELPHINUS
M-27
VULPECULA
SAGITTA
Altair
AQUILA
SERPENS
(cauda)
CAPRICORNUS
MICROSCOPIUM
M-11
SCUTUM
M-17
M-20
M-8
M-22
M-7
SAGITTARIUS
CORONA AUSTRALIS

The Star Dome shows how the sky looks at:
11:00 p.m. on August 1
10:00 p.m. on August 15
9:00 p.m. on August 31


URSA
CANES VENATICI
COMA BERENICES
Mizar
M-51
M-53
W
BOOTES
Arcturus
CORONA BOREALIS
SERPENS (Caput)
LIBRA
OPHIUCHUS
Antares
M-4
SCORPIUS
Shaula
1st magnitude and brighter
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

august sky almanac

1st	After sunset, a thin crescent Moon, Venus, Saturn, and Jupiter will line up in the western and southwestern sky.
2nd	This evening and tomorrow evening, the Moon (a wider crescent) will have passed Venus and will lie between it and the Saturn-Jupiter pair.
4th	The Moon will be seen to the east (left) of Jupiter and Saturn tonight.
7th	First Quarter Moon is at 3:26 p.m. EDT.
8th	The Moon is at apogee this morning: 251,175 miles.
10th	Mercury is at superior conjunction — in line with the Sun — and shifts from the morning sky to the evening. It will remain too close to the Sun to be seen for several weeks.
11th	Tonight and during the predawn hours tomorrow, the Perseid meteor shower will be at its peak.
15th	Full Moon comes at 12:37 p.m. EDT.
21st	The Moon is at perigee this afternoon: 229,691 miles.
22nd	Last Quarter Moon is at 10:16 a.m. EDT.
25th	Venus — which has been moving steadily closer all month — will be very near Jupiter and Saturn in the evening sky tonight.
26th	In the predawn hours this morning, the waning crescent Moon will lie close to Mars.
29th	New Moon is at 10:43 a.m. EDT.
30th	Sharp-eyed observers may catch Mercury appearing in the western sky right after sunset.
31st	The Moon will be close to Jupiter, Saturn and Venus just after sundown this evening.

Sundogs are colorful little "rainbows" that form when the air contains ice crystals of the proper shape. These primary sundogs lie 22° to each side of the Sun; if conditions are right, you will occasionally see a substantially fainter, secondary pair another 22° farther out. Photograph by Jack Newton.

brightest star of the summer constellations, stands right overhead as the night deepens.

Until it descends in the west, Vega is also the pinnacle of the prominent **Summer Triangle**, whose other members are **Deneb** and **Altair**. Vega shines in tiny but perfect **Lyra** the lyre (the legendary instrument of the great musician Orpheus, whose songs could make even the stones weep). Deneb is the tail of big and splendid **Cygnus** the swan, whose head is fairly bright **Albireo** — which some people think is the loveliest of all double stars in a telescope. Altair, about midway in brightness between Vega and Deneb, is located in **Aquila** the eagle. One of its notable attributes is its position directly between two relatively bright stars, which are perhaps shoulders (or outstretched wings) to the eagle's head of Altair.

Within the confines of the Summer Triangle are several faint but quite interesting miniature constellations. We will deal with these and also much more about Lyra, Cygnus and Aquila next month. But in our Milky Way exploration this month, notice the long narrow tongue of darkness which runs between Cygnus and Aquila, bifurcating the luminous Milky Way band. This is the **Great Rift**, caused by dark interstellar clouds of dust. The lesser channel of Milky Way flows on quite a distance, but trickles out in the area of big, loose **Ophiuchus** the serpent-bearer.

Just to the left of the wide part of the Rift is one of the few brightest areas of the Milky Way, a star cloud which almost overwhelms the pattern of foreground stars it immerses. The constellation is **Scutum** the shield; the bright patch is the **Scutum Star Cloud**.

Farther to the south, the Milky Way widens and we come to the splendid region of **Sagittarius** the archer — a place which suggests adventure and stirs the imagination, and which is therefore fittingly discussed in our section on skylore. But just to the west of Sagittarius, and in the direction of the concealed heart of our Galaxy, is our menacing but extraordinary friend **Scorpius**. Like Altair, the brightest star of Scorpius is flanked by two relatively bright stars. This lucida (brightest star) is the scorpion's heart, **Antares**, and so the other two are sometimes called the **Praecordia**, the outworks of the heart. Red Antares and the bright hook tail of Scorpius are prominent, but so is the head of Scorpius wherein lies **Beta** (β) **Scorpii** (Graffias), a star which has been famous since ancient times for being occulted (hidden) on occasion by the Moon, or even by planets.

skylore

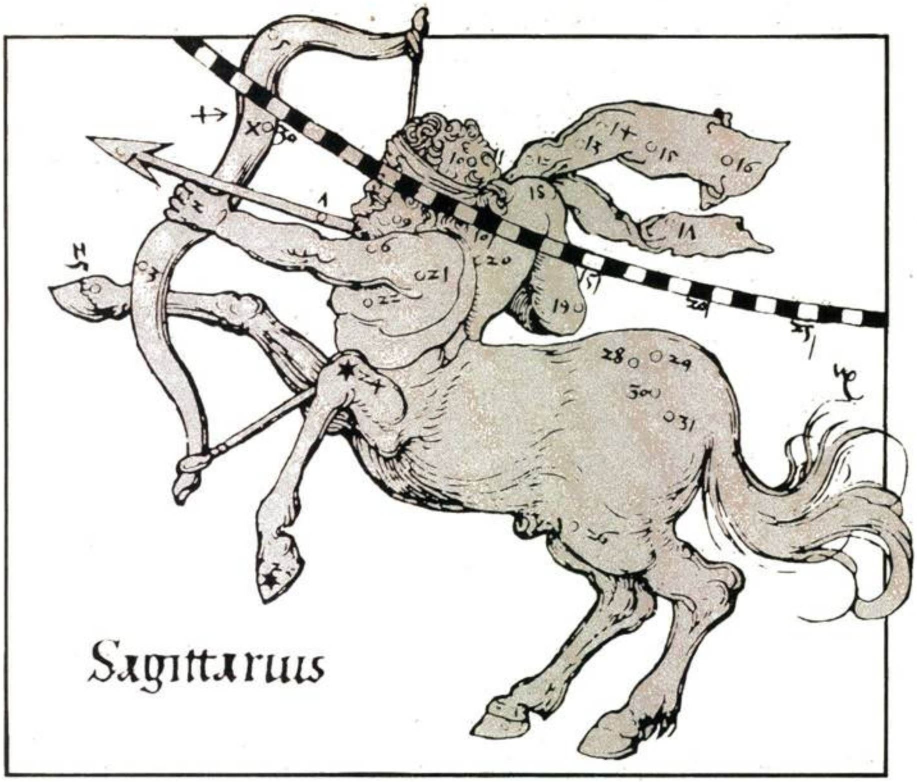
There are several hundred stars in the sky for which we have proper names. Only a few dozen of these, however, seem to be more useful (in some ways) than the scientific names, or designations, of these stars. Like all skylore, star names have an interest all their own, which goes beyond the merely functional. It seems to me, nevertheless, that there may be more situtations than we think in which star patterns and star names, connected with myths and legends, can be of practical value. And one of these situations, I believe, is the area of the constellation Sagittarius.

The Milky-Way-flooded region of Sagittarius seems almost like a wide, complex delta of the Heavenly River to mid-northern latitude observers — who can see little farther than this to the south. It is one of the richest areas of the heavens whether you use naked eye, binoculars or a telescope. But how do you find your way around this realm? If you are a telescopic observer, you might just dial the coordinates of everything you wanted to view, but in Sagittarius this would require a long list, difficult to memorize and which would have to be consulted each time. More importantly, you would have no perspective on where these glorious telescopic scenes were located in the naked eye panorama — they would be only a set of numbers, detached from you and the universe you should be feeling more a part of.

Using the scientific names of stars to find your way around Sagittarius is not very practical either. What was Johann Bayer thinking of when he assigned the Greek letters in this constellation? Alpha and Beta Sagittarii are quite faint objects, far away from the many brighter stars in the constellation, but also notice how seemingly haphazardly almost all the other Greek letters here have been assigned. There may be some semblance of logic, reason or order here, but if there is, it must be a secret code!

Many experienced observers rely heavily on the traditional patterns for guidance in their tours of this constellation. The most famous pattern, composed of almost all the brighter stars of Sagittarius, is the teapot, but another asterism is the smaller milk dipper, composed of Lambda, Phi, Sigma, Tau, and Zeta. For people who have "grown up" on the teapot, the milk dipper may not seem so obvious a pattern, but this is just cultural bias, because the Chinese long ago recognized a *Nan-tou* or southern dipper in these same stars (according to R. H. Allen) or in the same stars plus Mu Sagittarii (according to later researchers). Perhaps we should consider adding Mu and using this better-looking and more useful milk dipper. Robert Burnham Jr. has made his own suggestion how to extend the short handle of the traditional milk dipper — by continuining the handle, almost straight, to the glow of M-8, the Lagoon Nebula.

What other patterns do the stars of Sagittarius suggest? There are many ways to organize the stars here into its "proper" figure — a centaur archer — but most differ only slightly, and most are rather compelling likenesses (as such things go). The centaur is usually said to be Chiron, who now has a most peculiar solar system body (a trans-saturnian asteroid?) named after him, and whose interesting story we can investigate at another time. But where is the arrow in his drawn bow pointed to? Apparently somewhat south of the scorpion's heart, Antares.



Sagittarius is brimming with star clouds, star clusters and nebulae, some of which are visible to the naked eye — and can be fancifully and usefully associated with the imagined forms here. It is notable, for instance, that all of the bright nebulae in the Sagittarius area lie almost on the galactic equator and therefore in a straight line which directs us to the hidden multi-billion sun starball of the galactic center. What a glorious avenue to travel down — in another context Carl Sagan writes of "the night freight to the stars," but I have long thought of this stretch in Sagittarius as a kind of travelers' train run down the line to the hidden majesty of Milky Way Central.

But how do you locate this main thoroughfare of the Via Lactea (Milky Way) and readily find — even with the naked eye in country skies — such wonders as the Lagoon Nebula and the Small Sagittarius Star Cloud? These concentrations of brightness look like puffs of steam floating back in a gentle line from the teapot's spout — just beyond which lie the bright Large Sagittarius Star Cloud and the hidden galactic center. In a far older imagining, the entire Milky Way and especially the Large Sagittarius Cloud, were thought of as the smoke from Ara the altar, a constellation which precession has now dropped below the horizon of viewers in mid-northern latitudes.

Most of the objects I have so far mentioned are well-known and easily found in a quick telescopic sweep. But not many people might be able to identify them or their positions with the naked eye. The naked-eye view in dark skies is rich enough to be confusing and a star name or two would be welcome here. There is only one fairly bright star in the "Nebula Row" stretch from M-16 to M-8 and this important object is Mu Sagittarii — which we find if we extend the milk dipper as suggested above. But Mu also has a proper name, Gau, according to one source. The name is supposedly Persian for Bull, after a "lunar mansion" located in this area.

Another, almost totally forgotten but useful, name is Al Baldah ("city" or "district") for Pi Sagittarii. Al Baldah is one of the few brightest stars within several degrees of the ecliptic, shining at magnitude 2.9, right beside several other prominent stars. But these three, and some fainter ones nearby, seem little regarded by observers today, probably because they are not known to be of telescopic interest, and fall outside the famous teapot. The fact that Pi is named indicates that it was not always ignored, nor should be — these stars could form a fairly prominent constellation of their own if fortunes had been different.

Further investigation of star names and asterisms in lore books can clarify and enrich our tours of the heavens. On your next outing (especially in clear, dark skies) try to indentify more stars by their proper names and find out-of-the-way asterisms of your own to locate on maps (you will "discover" some double stars and naked-eye clusters in this manner). This is the best way to learn, because in doing so you will be making the stars a true adventure for you to experience personally.

ASTRONOMY IN FOCUS

More Moons

Sir / In conjunction with John Mood's letter (In Focus, April '81) on the correct pronunciation of Saturn's moons, and in light of the Voyager 2 go-ahead to Uranus, I have compiled a list of pronunciations for Uranus' five moons. They are taken from popular modern American English dictionaries.

Ty-TAY-nee-uh or Tih-TAY-nee-uh for Titania
OH-beh-ron for Oberon
AIR-ee-uhl for Ariel
Um-BREE-uhl for Umbriel
Mir-AN-duh for Miranda

Keep these in mind as Voyager nears its rendezvous with Uranus in 1986.

Paul L. Noble
Los Altos, CA

Mood's Moons

Sir/ In ASTRONOMY of April 1981, John Mood rightly breaks a lance for correct pronunciation of the names of Saturn's moons and then ruins the argument by calling the anglicised pronunciation of Latin correct. Without losing his spirit of patience, kindness and understanding, I wish to point out that what English-speaking people do to Latin and Greek rings harshly on the ears of anyone with a classic education free from Anglo-Saxon idiosyncrasies!

It is not true we can never know how the Romans spoke their own language — or the Greeks, for that matter. Philology can tell us, for instance, that the Latin "C" was never pronounced as the English "see" because the Romans had the letter "S" for that sound. It was pronounced as a "K," which the Romans did not have. The combination "AE" was definitely never pronounced as the "EE" in the word "see" because the Romans had the letter "I" for that sound. It was pronounced "AI" as in the Chinese word *taifun,* which became the English typhoon. The Romans, therefore, pronounced Caesar simply as the German word Kaiser, which is how the Germans acquired it.

Latin is not dead; it thrives today in about a half dozen European languages. These tell you, for instance, that the Latin "I" is absolutely never pronounced as "AI" (as in "mine"). In fact, not a single people or tribe all over the world has ever done this except some oddballs from an island in the North Sea and their proliferating progeny. It might be quite possible that the JPL scientists pronounced the names differently because they were educated in Europe or through European contacts had heard the correct pronunciation! Most of the "incorrect" pronunciations John Mood mentions are in fact halfway correct, and all pronunciations given by the dictionary are indeed modern American English — but not the classic Latin and Greek which the words are.

So if you wish to keep Augustus and Homeros (which is what these blokes called themselves) from turning in their graves:

Io is called EE-oh and never EYE-oh;

Mimas is called MEE-mas and never MY-mas;

Enceladus is really called En-KAY-lah-doos (as in rook);

Dione said her name was DEE-oh-ne;

Rhea answered to the call RAY-ah (with blown R);

Iapetus prefers JA-pay-toos (German "ja" and English "rook");

Phoebe is bad: FOI-buh is the only correct way.

If Titan was "fortunately never called TEE-tan" I say woe unto thee, because that would have been exactly right. Witness the way in which Italians, Spaniards, Portuguese, Germans, French, Dutch, Scandinavians and even all the speakers of Slavic languages treat this word. What's more, Greeks still say TEE-tan. Again, with perfect logic, the Romans wrote Phoebe (FOI-buh) for the Greek *φοιβη*. And the same applies to the phoenix which was *φοινιξ*.

It's with Tethys that astronomical literature seems to go off the rails altogether, because an astronomical body called Tethys cannot exist. According to the rules, this category of astronomical names derives from mythology, and there is no such person. There is a lady called Thetis, however, and she is the mother of Achilles, no less. This is a persistent error in Anglo-American literature which I've never seen in German or French publications. You will find her under the letter theta and not under tau, about half a dictionary's difference — like looking for the word "thisgraceful." Greeks pronounce it THAY-tiss, with the Anglo-Saxon "th" they also have. To top it all, Saturn is itself an abomination because this character called himself Saturnus (sah-TOOR-noos with two "rooks").

The moral? Although English has an astonishing percentage of straight Latin thrown in (more than any other language if I'm not mistaken and more than a so-called Romance language such as French), it is about the worst background for a correct pronunciation of the old words used for our strange new worlds.

Frithjof Sterrenburg
Sijbekarspel,
The Netherlands

VEE-king Moons

Sir/ Regarding the mis(?) pronounciation of the names of Galilean moons and similar worlds, I must point out that although English is a pleasant language (which I myself have only half-mastered), it ranks, in terms of spelling and pronunciation, easily among the weirdest ones in the Indo-European family of languages. A splendid illustration of this is the way English-speaking people pronounce the word "viking." A descendant of them myself, I know that the correct pronunciation is "VEE-king." In Swedish, as in Spanish, French, German, Italian, Greek or any other Indo-European language except English, the letter "I" is pronounced "EE."

Of course, we are all entitled to our own little pronunciation peculiarities (we Swedes have them too, although not nearly as many as you do). However, since the original Latin pronunciation of the name "Io" undoubtedly sounded a lot more like "EE-oh" than "EYE-oh," and since the rest of the world has remained true to the original pronunciation, "EE-oh" rules in time and space. As for Tethys, the original pronunciation would be "TEH-thees" or even "TEH-tees." In the case of Enceladus, I have no idea where the Romans put the stress, but otherwise it probably sounded like "En-kell-ah-dohs."

Ann Sidbrant (AHNN SEED-brahnt)
Malmo (MAHL-moe)
Sweden (SVEH-ree-yeh)

Northern Lights by Air

Sir / At 11 p.m. on April 12, 1981, I left Chicago aboard a commuter flight and got a beautiful view of the Northern Lights. I have seen them before, but had I not recently read an excellent and very technical article on the aurora, I would not have thought it was so bright and seemed so close.

The reddish pinks filled 50° of the field of view beginning about 45° above the horizon and were incredibly bright despite an eight-day-old Moon. Greens and blue greens were on the horizon.

About 20 minutes into the show almost exactly at the zenith (the aircraft design allowed us to see directly above us), we were showered with another onset of the red-pinks. It was very similar to the Trifid Nebula in shape but monochromatic, and it was almost like looking down a tunnel. Ten minutes later the reds filled 120° of azimuth at about eye level. It was fantastic!

I wish all the people who read this magazine could have been on the flight.

Raymond Brooks
Terre Haute, IN

Unite and Save the Space Program

Sir / I was very pleased to see ". . . Save the U.S. Space Program" in the May 1981 issue of ASTRONOMY. I have written all of the senators and congressmen on the list. I have also written all of the societies listed to ask why they have made no effort to consolidate into one large, highly visible organization. If the AMA were similarly fragmented into small groups of doctors supporting their individual specialties, we would have socialized medicine tomorrow. If we are to effectively support the space program, we must unite our various factions. Through lobbyists, we must make it known in Congress that those members who do not support an aggressive space program will have many thousands of votes cast against them in the next election. Money spent to get this message across would, I believe, be more effective in furthering our cause than that spent in token financial support of individual space missions. In short, to have true political clout we must first learn to apply the techniques of other already established and successful special interest groups. Let's stop being so politically naive and get our act together.

William Blair
Morton, IL

The Realm of the Galaxies

Sir / While scanning over the April Star Dome (page 32), I noticed the section of sky between Leo and Virgo labeled "the Realm of the Galaxies."

Would it happen to be an area where there is a treasure-house of galaxies, an assembly of super-galaxies, or simply your April Fool's prank?

Matthew Tolbert
Lancaster, PA

Mr. Tolbert / The area you mention is indeed a place on the sky where a great many galaxies can be seen. More specifically, it is a collection of some 3,000 galaxies known as the Virgo cluster. The cluster lies at a distance of some 70 million light-years and, in cosmic terms, is pretty close to our Milky Way. A 6-inch telescope will start to reveal the galaxies, but you'll need larger apertures to see very many cluster members. Our label, "Realm of the Galaxies," harks back to a 1936 book by Edwin Hubble in which he described what galaxies were, how far away they lay, and classified their shapes. Following the astronomical parlance of his time, Hubble called galaxies "nebulae," and so his book was titled **The Realm of the Nebulae**. *It's a classic.*

behind the scenes

back in space with shuttle

Even as we publish the story of the first flight of *Columbia*, many readers are anticipating its second flight, now scheduled for September 30. In this respect, the Shuttle marks a new presence in space for the United States — an airline for routine placement of communications satellites, civilian and military Earth surveillance instruments, and scientific satellites.

But in our enthusiasm, we must not forget that this is a very different kind of presence in space than the exploratory missions of Pioneer, Mariner, Viking and Voyager. The Shuttle is a "coastal trader," if you will, carrying cargo from port to port, not an explorer's ship setting sail across unknown oceans in hope of discovering new worlds.

While the Shuttle is vital to our country, we must not allow its success to blind us to the sorry state of the other side of our space program. We must continue to tell our elected representatives that we want exploratory missions to Jupiter, Venus, and Comet Halley; that we do not want Voyager to become the last act of a dying space program.

ASTRONOMY's coverage of the August 26 Voyager 2 encounter with Saturn will appear in our November issue. Let me explain why: after closest approach on the 26th, photos and science results will be available by the 30th. By then, your September issue will have arrived. We will have already completed the October issue two weeks earlier, and it will be almost ready to print. Although October may have some preliminary results, the November and following issues will thus carry the major part of our coverage.

Sincerely,

Richard Berry

Richard Berry
Editor

Come explore a comet.

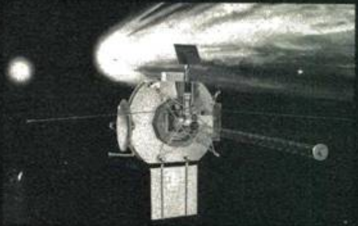
Halley's Comet returns in 1985. The Europeans, the Soviets, and the Japanese are readying spacecraft to meet it. Of the technological powers, only our nation plans to watch from afar. Why? Our space program is dying.

Over the last decade, NASA's purchasing power was slashed again and again while the rest of the federal budget mushroomed. Twice NASA tried to get funding for missions to Halley's, and twice the budget cutters looked at the dollars and not at what they'd buy. Now the only U.S. representatives at this comet will be the few American scientists associated with the European mission. And it doesn't appear that our government will even fund them properly.

Our space program has strong supporters in the government who could add a Halley Intercept Mission (HIM) to NASA funding. For them to do so in this budget cutting year, however, they need proof to show their colleagues that the public supports space exploration.

Last year 10,000 people used the Viking Fund to begin giving that proof. They dug into their pockets and gave an average of $10 apiece to support one starving project: the Viking lander on Mars. Today, their money is helping pay the costs of collecting and analyzing Viking's data.

Now the organizers of the Viking Fund announce the Halley Fund. Its goal: Show popular support for HIM by actually helping pay for it. By sending a few dollars to the Halley Fund, you can let the politicians know that you want an American mission to Halley's comet. We'll see that your money helps pay for HIM. And if the mission doesn't make it into the budget, your money will support American scientists associated with the European probe.



At stake is more than America's prestige. Even with other nations sending probes, the scientific value of a sophisticated American probe is unquestioned. The real question is whether the U.S. has the resolve to explore the solar system.

So come explore a comet.

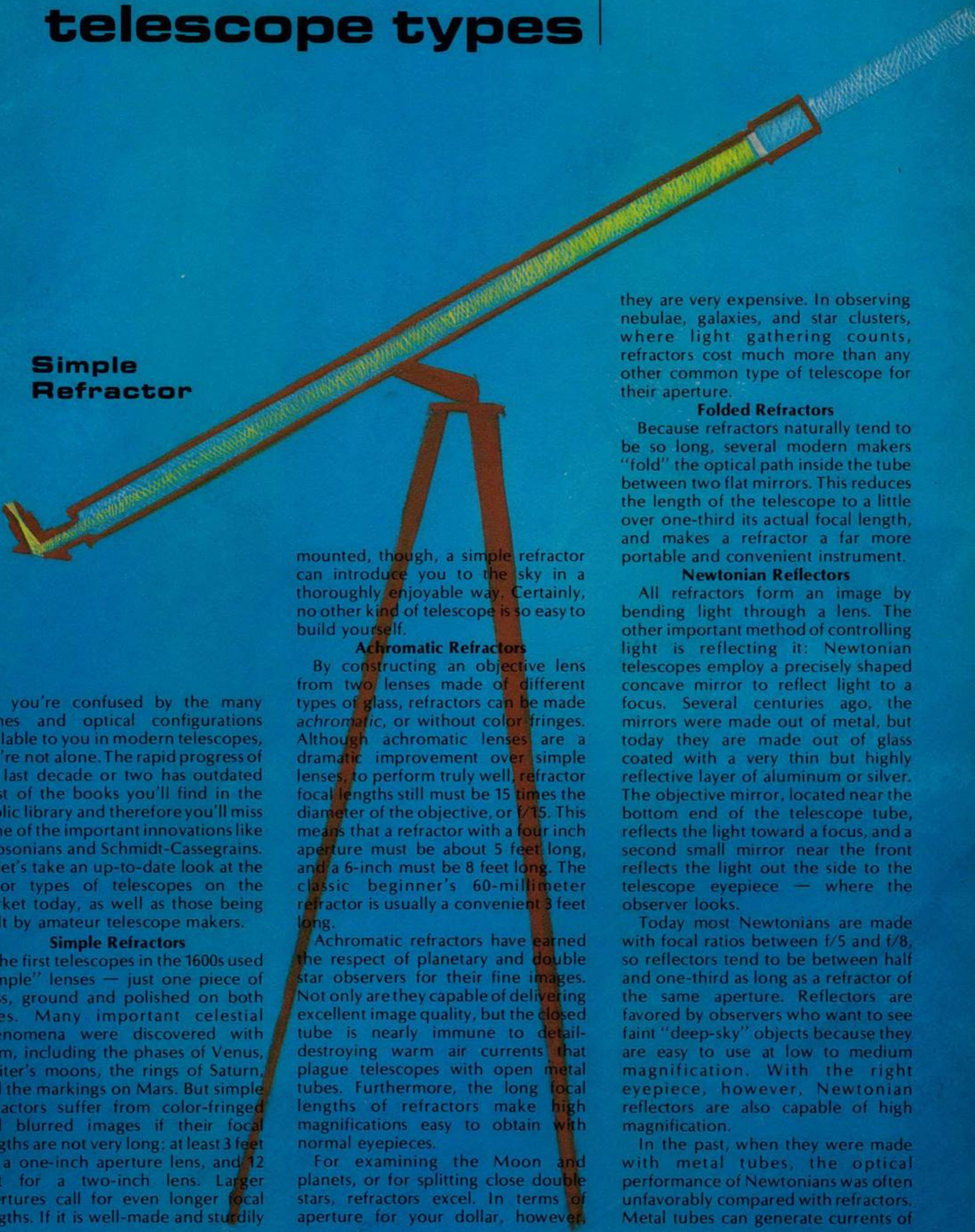
Send your tax deductible contribution to the Halley Fund ($1 minimum), and you'll receive regular updates on the plans of all nations to explore Halley's comet. Don't delay. If Congress doesn't add money to NASA's budget for HIM this summer, your next chance to explore Halley's will come in 76 years.

And save our space program.

THE HALLEY FUND

Dept. A • 357 Saratoga Avenue
Santa Clara, CA 95050

beginner's guide to telescope types



If you're confused by the many names and optical configurations available to you in modern telescopes, you're not alone. The rapid progress of the last decade or two has outdated most of the books you'll find in the public library and therefore you'll miss some of the important innovations like Dobsonians and Schmidt-Cassegrains. So let's take an up-to-date look at the major types of telescopes on the market today, as well as those being built by amateur telescope makers.

Simple Refractors

The first telescopes in the 1600s used "simple" lenses — just one piece of glass, ground and polished on both sides. Many important celestial phenomena were discovered with them, including the phases of Venus, Jupiter's moons, the rings of Saturn, and the markings on Mars. But simple refractors suffer from color-fringed and blurred images if their focal lengths are not very long: at least 3 feet for a one-inch aperture lens, and 12 feet for a two-inch lens. Larger apertures call for even longer focal lengths. If it is well-made and sturdily mounted, though, a simple refractor can introduce you to the sky in a thoroughly enjoyable way. Certainly, no other kind of telescope is so easy to build yourself.

Achromatic Refractors

By constructing an objective lens from two lenses made of different types of glass, refractors can be made *achromatic*, or without color fringes. Although achromatic lenses are a dramatic improvement over simple lenses, to perform truly well, refractor focal lengths still must be 15 times the diameter of the objective, or f/15. This means that a refractor with a four inch aperture must be about 5 feet long, and a 6-inch must be 8 feet long. The classic beginner's 60-millimeter refractor is usually a convenient 3 feet long.

Achromatic refractors have earned the respect of planetary and double star observers for their fine images. Not only are they capable of delivering excellent image quality, but the closed tube is nearly immune to detail-destroying warm air currents that plague telescopes with open metal tubes. Furthermore, the long focal lengths of refractors make high magnifications easy to obtain with normal eyepieces.

For examining the Moon and planets, or for splitting close double stars, refractors excel. In terms of aperture for your dollar, however, they are very expensive. In observing nebulae, galaxies, and star clusters, where light gathering counts, refractors cost much more than any other common type of telescope for their aperture.

Folded Refractors

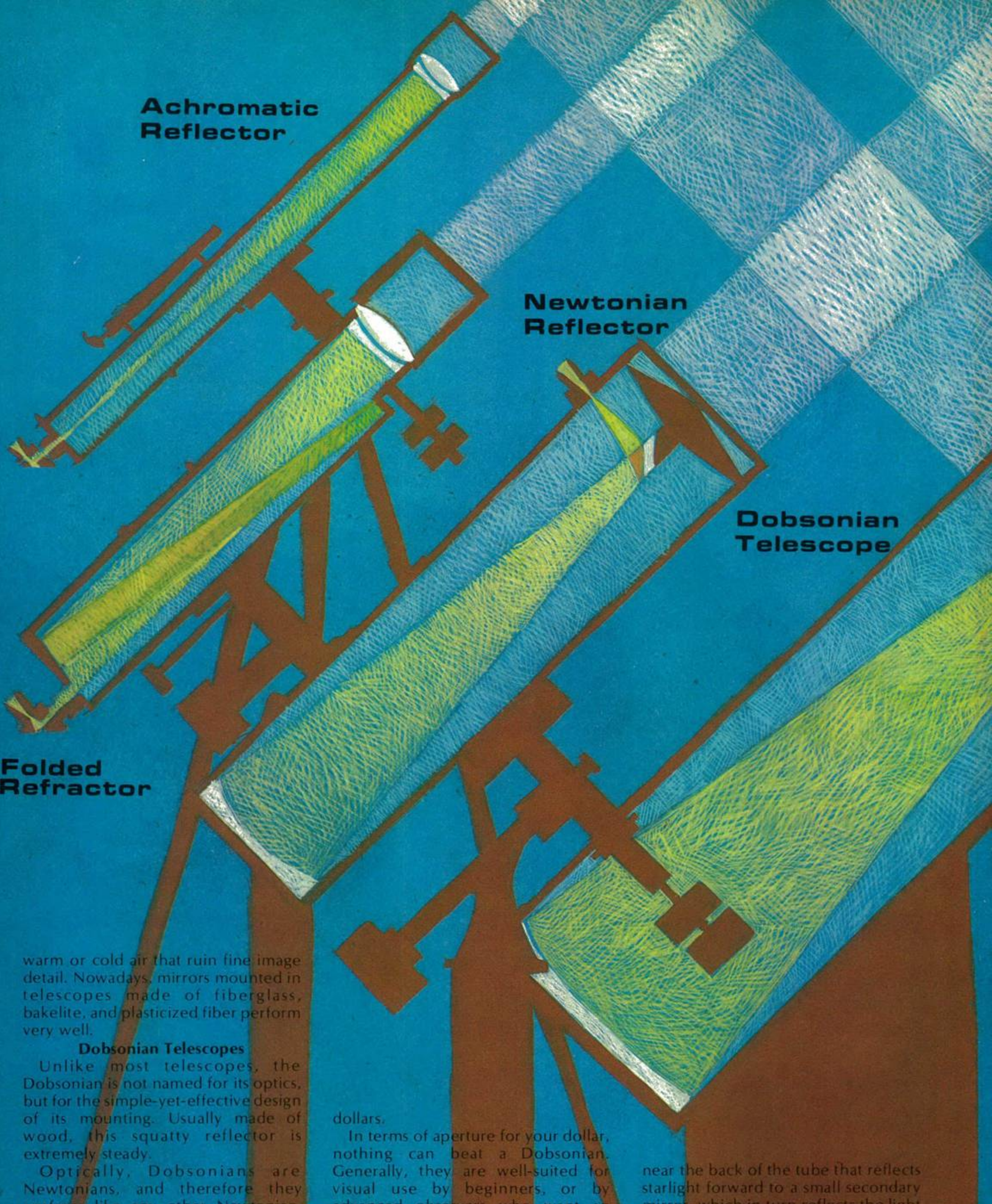
Because refractors naturally tend to be so long, several modern makers "fold" the optical path inside the tube between two flat mirrors. This reduces the length of the telescope to a little over one-third its actual focal length, and makes a refractor a far more portable and convenient instrument.

Newtonian Reflectors

All refractors form an image by bending light through a lens. The other important method of controlling light is reflecting it: Newtonian telescopes employ a precisely shaped concave mirror to reflect light to a focus. Several centuries ago, the mirrors were made out of metal, but today they are made out of glass coated with a very thin but highly reflective layer of aluminum or silver. The objective mirror, located near the bottom end of the telescope tube, reflects the light toward a focus, and a second small mirror near the front reflects the light out the side to the telescope eyepiece — where the observer looks.

Today most Newtonians are made with focal ratios between f/5 and f/8, so reflectors tend to be between half and one-third as long as a refractor of the same aperture. Reflectors are favored by observers who want to see faint "deep-sky" objects because they are easy to use at low to medium magnification. With the right eyepiece, however, Newtonian reflectors are also capable of high magnification.

In the past, when they were made with metal tubes, the optical performance of Newtonians was often unfavorably compared with refractors. Metal tubes can generate currents of



warm or cold air that ruin fine image detail. Nowadays, mirrors mounted in telescopes made of fiberglass, bakelite, and plasticized fiber perform very well.

Dobsonian Telescopes

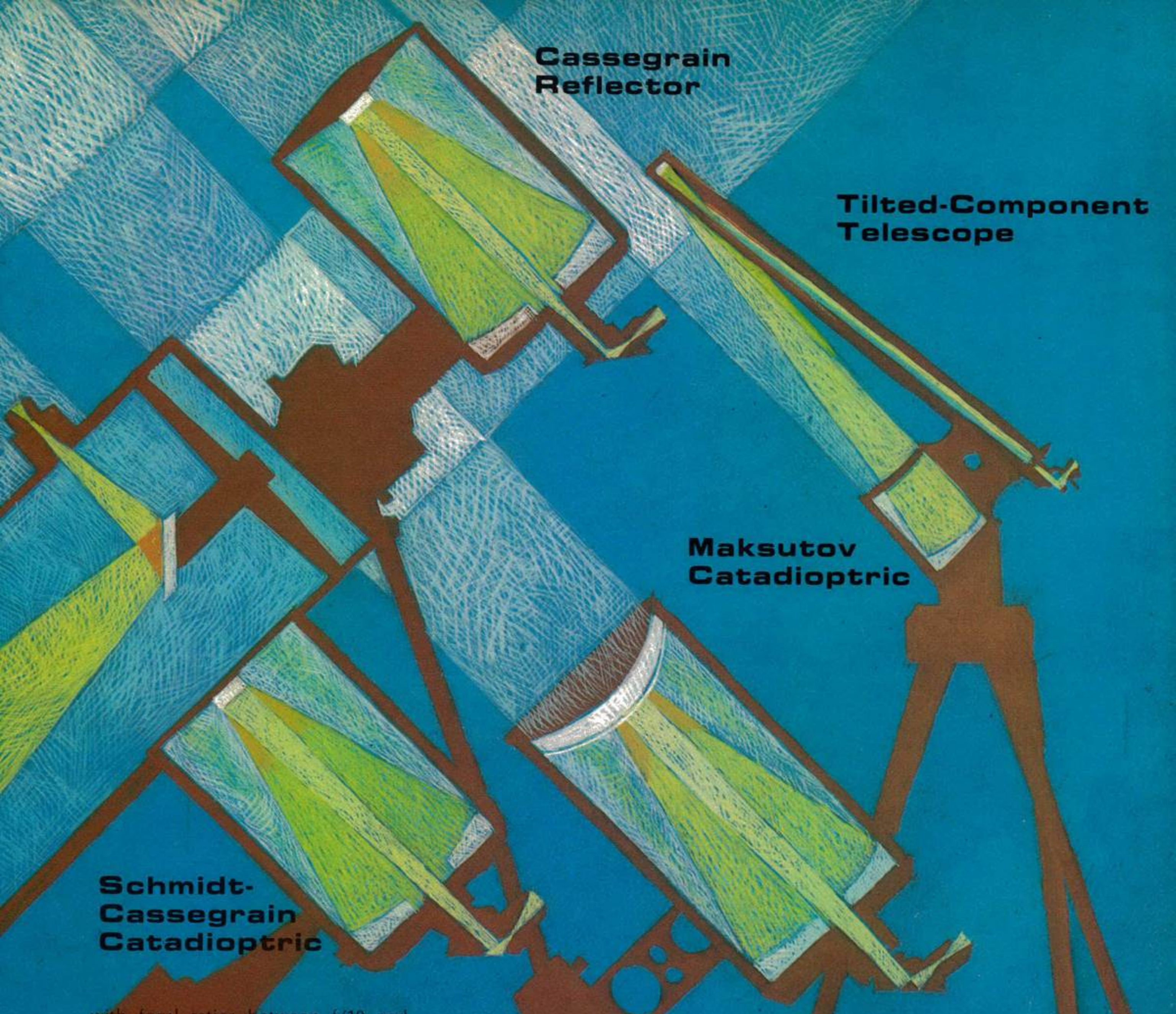
Unlike most telescopes, the Dobsonian is not named for its optics, but for the simple-yet-effective design of its mounting. Usually made of wood, this squatty reflector is extremely steady.

Optically, Dobsonians are Newtonians, and therefore they perform like any other Newtonian. Additionally, their mountings are easy to set up and use. Dobsonians make excellent first telescopes, because unlike many first telescopes, you can build one with an aperture as large as ten inches in your basement workshop at a cost of only several hundred dollars.

In terms of aperture for your dollar, nothing can beat a Dobsonian. Generally, they are well-suited for visual use by beginners, or by advanced observers who want an inexpensive large aperture telescope.

Cassegrain Telescopes

For long focal lengths with a reflecting telescope, astronomers frequently choose one of the Cassegrain optical designs. Cassegrain telescopes have a large primary mirror near the back of the tube that reflects starlight forward to a small secondary mirror, which in turn reflects the light through a hole in the primary mirror and out the back of the telescope to the eyepiece and the observer. Because Cassegrains have folded optical paths, their tubes are much shorter than the actual focal length of the telescope. Usually they are built



with focal ratios between f/10 and f/20, with f/16 being the most popular.

Of course, the long focal ratio of a Cassegrain tends to suit it best for the medium and high magnifications used in lunar and planetary observing. Professional astronomers prefer the Cassegrain design because the tube is short and the focus is located rather conveniently behind the telescope — an important consideration with a very large reflector.

There are three common varieties of Cassegrain telescopes: the classical Cassegrain, the Dall-Kirkham Cassegrain, and the Ritchey-Chretien Cassegrain. The precise shapes of the mirrors differ slightly, yielding different optical characteristics.

In a classical Cassegrain, the mirror is paraboloidal, as a Newtonian primary is, so the telescope can be converted to a Newtonian for low-power observing.

In a Dall-Kirkham Cassegrain, the secondary mirror is spherical, a shape which is easy to make, and the primary is ellipsoidal, a figure which is easy to test. The edges of the images aren't as good as a classical Cassegrain can produce, but the ease of fabrication of the mirrors makes up for it.

Ritchey-Chretien Cassegrains produce an exceptionally wide field for photography, and can also be made to lower f/ratios than other Cassegrain systems — usually f/6.5 to f/7.5. Professional astronomers prefer this type, which is difficult to make, but becomes practical in large apertures.

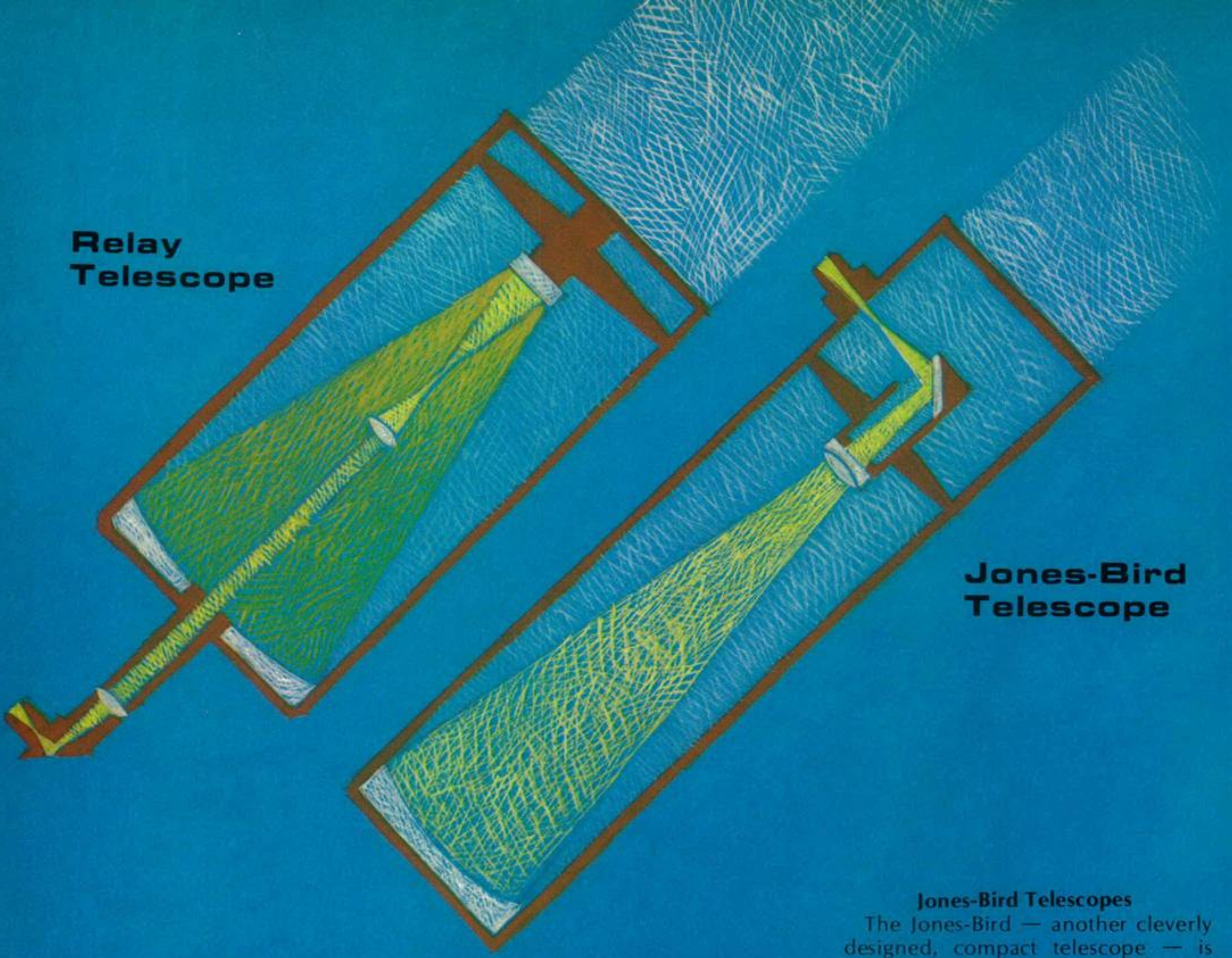
Tilted-Component Telescopes

To avoid the slightly degraded images caused by secondary mirrors in the light path in most reflecting telescopes, optical designers created a class of telescopes using tilted mirrors. These are called TCTs. There are many types, but in all of them starlight bounces from one mirror to the next to a focus. Two or three mirrors are used.

No other class of telescope produces images as beautiful as a TCT does. Only TCTs have apertures that are completely unobstructed and completely free of residual "color errors." TCTs are not easy to make, however, so none are commercially available. In the hands of a dedicated amateur telescope maker, however, TCTs really shine.

Maksutov Telescopes

Maksutovs are another kind of Cassegrain telescope, but they also belong to the class of catadioptrics, or telescopes with both lenses and mirrors in the optical system. At the front of the tube is a correcting lens, a thick deeply curved piece of high-grade optical glass. Starlight passes through the correcting lens — where it is bent very slightly — to the main mirror, then back to a spot of metal coated on the correcting lens, and finally out the rear of the telescope.



Maksutov telescopes provide a long focal length in a short tube. Several years ago most were f/15, but lower f/ratios have appeared in the last few years. "Maks" are mechanically rugged and thus are well suited for use as telephoto lenses for cameras as well as for telescopes.

Schmidt-Cassegrains

Unlike the thick glass corrector of a Maksutov, a Schmidt corrector is thin. It has a complex curve polished into its surface that compensates for the aberrations of an easy-to-make spherical primary mirror. As in other Cassegrains, the starlight exits the back of the instrument.

Schmidt-Cassegrains were once rare, expensive, and difficult to produce — in fact, they were built one at a time. But they are now mass-produced and have become common. Because the optical path is folded, the tubes are short and lightweight. Almost all Schmidt-Cassegrains are f/10 — so using them at low magnification is rather difficult — but they are ideal for medium and high magnification viewing.

Don't confuse Schmidt cameras with Schmidt-Cassegrains. Schmidt cameras are not telescopes. They are cameras and can be used only for taking pictures. Employing the same Schmidt corrector plate they make for their telescopes, several manufacturers sell these cameras ready-made. Starlight passes through the corrector to the main mirror, where it is reflected to form an image on a photographic film located in the middle of the tube. With these "fast" cameras, exposures of sky objects can be made quickly — in only a few minutes.

Relay Telescopes

For enthusiastic home telescope builders, relay telescopes offer an interesting challenge. Usually, the designer's goal is to make the primary an easy-to-make spherical mirror. Two lenses and a secondary are simpler and require less expensive optical glass than the rather difficult full-size lenses of Maksutovs and Schmidt-Cassegrains.

Starlight reflected from the primary mirror goes to a mirror/lens secondary at the front of the tube, then through the two small lenses — the first the field lens, and the second, the relay lens — which refocus the light to a crisp image at the eyepiece.

Jones-Bird Telescopes

The Jones-Bird — another cleverly designed, compact telescope — is marketed in Japan and Europe, but not the United States. It uses a spherical primary mirror and an achromatic lens placed inside the tube to form a sharp image suitable for photography or viewing. From the outside, a Jones-Bird telescope looks a lot like a Newtonian, but it's about half the length of a Newtonian with the same focal length. They are f/9, but other focal ratios are possible.

Of course, there are many other types of telescopes and many other optical systems. In TCTs alone, for example, there are dozens of different variations of the basic theme. But you might never see one of them — for they are quite rare — each the work of a dedicated telescope builder. Today the Newtonian predominates, while the Schmidt-Cassegrains have largely replaced the Cassegrains that were fairly popular only a decade ago. Refractors — years ago the most common of all telescopes — now seem to be an endangered species despite their sterling qualities. Dobsonians are becoming more and more popular because they offer so much aperture at such a low price. Meanwhile, on drawing boards and in the workshops of amateur telescope makers, many other interesting types of telescopes wait for their day of glory.

— *Richard Berry*

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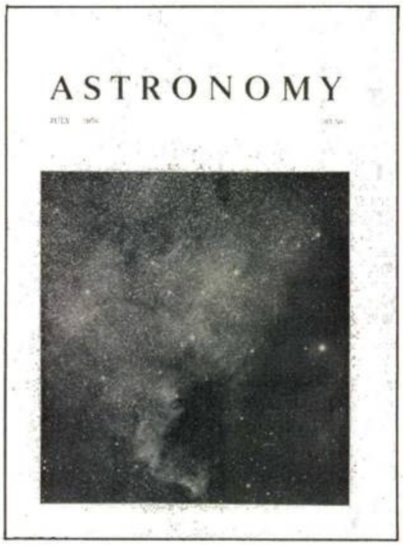

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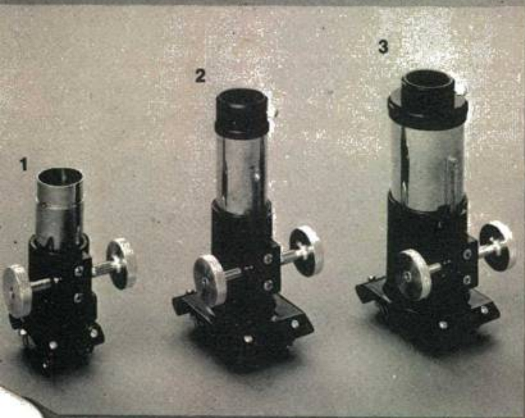

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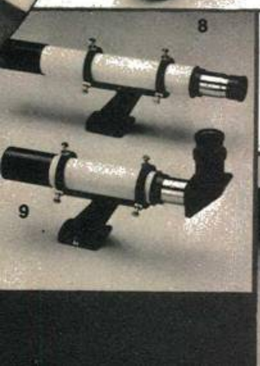

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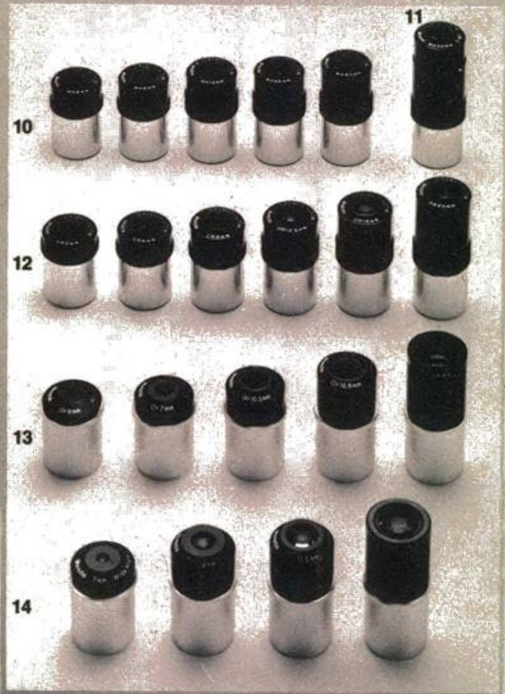

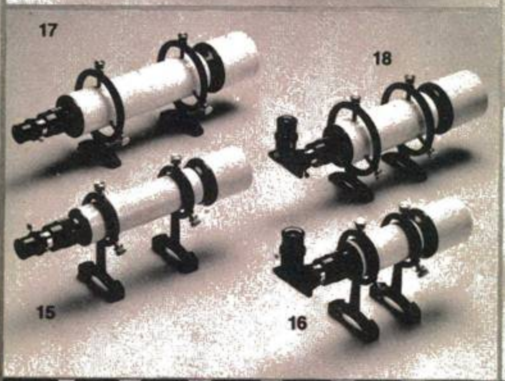

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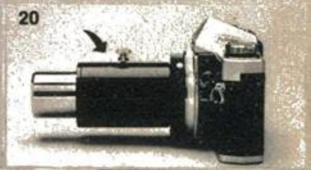
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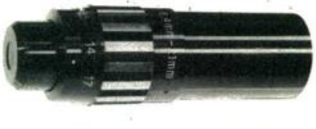

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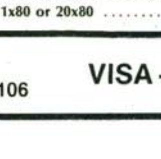

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big binocular astronomy

by John Sellers

In the last few years, 80-mm binoculars have become a prominent part of the telescopes-and-accessories market. You might be thinking of buying a pair or wondering what they are or what you might use them for.

Light grasp apart, 80 mm binoculars are basically no different than their smaller cousins, the 35 mm to 70 mm aperture models. But 80 mm binoculars collect 1.3 times as much light as a 70 mm pair, over 2½ times as much light as a 50 mm pair, and over 5 times as much as a 35 mm pair. As with all binoculars, you get an erect (upright) image. Magnifications range from about 10x to 30x, and prices typically vary from $150 to $350.

From an astronomical standpoint, a pair of binoculars is a small aperture, portable rich field telescope. In addition to their portability, binoculars have a further advantage over ordinary RFTs — you can look through two telescopes at once. This won't provide any depth perception, but many people find that putting both eyes to work causes less eyestrain.

When you view with binoculars, you should have them mounted in some manner. Ten power is tops for unsupported hand-holding and even then you're crowding the limit. You'll hear claims that so-and-so can hand-hold his 20 x 70s "rock-steady" — but ask him how long he did it and how much he actually saw.

Photo-tripods can support 80 mm binoculars sufficiently, but only if the tripod is sturdy. You can buy an adapter that clamps onto the center shaft of the binoculars and has a standard ¼-20 threaded socket in the bottom for the tripod screw. Power Optics (P.O. Box 953, Brandon, FL 33511) sells one for $6.

Why all the fuss over steadiness? Just as with regular telescopes, a quick glance never does the object justice. You should observe in comfort without the strain of trying to hold the binoculars steady. With your binoculars securely mounted, observing is more fun. You spend more time looking, and you see more.

And what can you see? Nearly every type of object! Binoculars work on galaxies, open and globular clusters, diffuse nebulae, double and variable stars — even planets. Only objects that need large aperture or high power (like the dimmer galaxies or planetary nebulae) lie beyond the capabilities of binoculars. In some cases, you'll find large binoculars provide an even more pleasing view than a regular telescope would.

are big ones necessary?

No. If you have a pair of small binoculars around the house already, it's silly to rush right out and buy a bigger pair. Take your small pair (6 x 35, 7 x 50 — whatever) and use them all you can. There are two good reasons for doing this.

First, you save money — a good idea in itself — and you can put the savings toward something else, perhaps a star atlas. Second, you'll have lot of fun with them just as they are. To improve on a pair of 6 x 35s as much as they improve your naked eyesight, you'd need a 6-inch telescope. Taking that first small step beyond unaided eyesight will reveal a lot.

Later, after you've had a chance to get the most from what you have, you might consider purchasing a larger pair.

For example, the Pleiades — which overflow a telescopic field of view — are absolutely stunning in 11 x 80 binoculars. The field of view is just wide enough to fit in the entire cluster, and the stars look like diamond studs on black velvet. Under extremely clear conditions with a totally dark sky, you'll probably pick up some of the nebulosity that envelops the cluster.

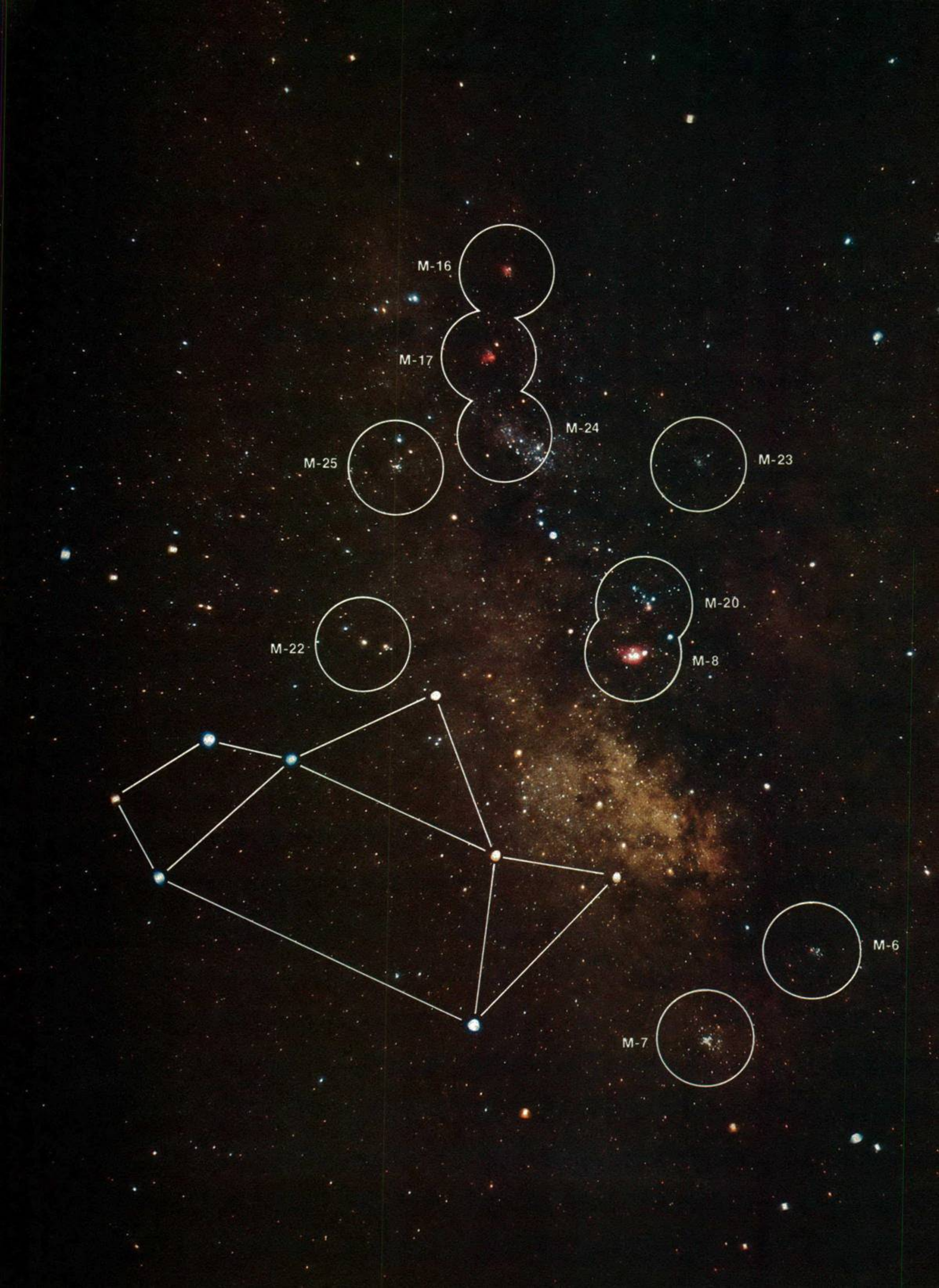
The Andromeda Galaxy (M-31) is another fine object for binoculars even without a superb sky. But under excellent conditions, you can easily trace its faint extensions from the dense core to an overall length of three degrees or more. Some observers have reported seeing hints of dust lanes.

For an awesome experience, try sweeping the length of the Milky Way on a clear, moonless night. Through the binoculars, countless stars will pepper the background. As you sweep along and find an interesting spot, stop and concentrate a moment. Try to see beyond your first impressions; soon objects will appear that you might have skimmed past and left unnoticed before.

Many observers often overlook searching the Milky Way for the dark dust nebulae that interlace our Galaxy. These dust lanes swirl through the Galaxy's spiral arms and block the light of distant stars. Besides your naked eye, large binoculars are best for seeing them. When you search, focus on areas like that between Scutum and Sagittarius, where the star clouds lie densely packed.

The North America Nebula (a diffuse nebula) and the Veil Nebula (a supernova remnant) are two other fine targets for large binoculars. With these, you won't need a lot of magnification, but rather a wide field of view.

Inexperienced observers often miss the North America Nebula — even when they know its precise location and are looking directly at it. The nebula blends elusively into the background stars and its North America shape is difficult to detect. Look for it about 3° southeast of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Deneb (Alpha [α] Cygni).

The Veil Nebula is a real challenge, and you'll get results only under the darkest skies and with the best conditions. Find it by locating the eastern star in Cygnus' crossbar (2.5 magnitude Epsilon [ε] Cygni). About 3° directly south lies 4.2 magnitude 52 Cygni. The western part of the Veil Nebula passes very close to this star, the other half lies 2° to the northeast.

Globular clusters look like tiny round balls of smoke in binoculars. Try looking for M-13 in Hercules, which lies about 2° due south of 3.5 magnitude Eta (η) Herculis — the upper right star in the constellation's "keystone." Or try for M-15 in western Pegasus: look 4° to the northwest of 2.4 magnitude Epsilon (ε) Pegasi.

Though most double stars will require the powers of a telescope, many "binocular doubles" will provide you with hours of entertainment. To mention just one, Albireo (Beta [β] Cygni) is a most satisfying double star — 11 x 80s will just split the pair. The view is unforgettable. Both stars appear "almost-one-but-not-quite," and their different colors (blue and gold) provide a beautiful color contrast.

Many variable stars fall wholly or partly into the grasp of even a small pair of binoculars. Mira (Omicron [o] Ceti) is a famous example and the first star known to be variable. Mira, in the "tail" of the constellation Cetus, ranges from about magnitude 3 at brightest down to about magnitude 10 at dimmest, over a period of 330 days. Maximum brightness comes in the middle of this month, and thereafter the star will slowly decline to minimum (in March or April next year).

Don't overlook the Moon and planets, either. In 20 x 80s, the Moon appears strongly 3-dimensional — especially at crescent phase when it glows with earthshine. As the terminator marches westward across the Moon's face, the larger craters (Theophilus, Clavius, Copernicus) and mountain ranges will stand out and you'll see many more of both down to the limit imposed by magnification.

Jupiter and its four Galilean moons are readily visible and following the back-and-forth motions of this "solar system in miniature" is always fun. Since their positions change over the course of a few hours, they provide an absorbing and endlessly varied spectacle. Saturn and its biggest moon, Titan, lie in the grasp of 20 x 80s, but the rings are marginal at present because we are seeing them too close to edge-on.

Venus, too, provides interesting viewing. Can you make out its changing phases? It may be difficult with 11 x 80 binoculars, but try it with a pair of solidly mounted 20 x 80s — especially as summer moves on into autumn. Then Venus will be closing in on the Earth, readying for its passage between the Earth and Sun in January 1982. By late fall, its size, brightness, and phases will be changing from week to week.

A great many would-be observers find their interest in astronomy stifled because they can't afford a telescope — and they don't think of binoculars. The sky is filled with thousands of objects that lie just beyond the reach of the naked eye — why not make a smaller investment in a pair of binoculars and go looking for them?

John Sellers is an Instructor at James Madison University in Harrisonburg, Virginia. Though interested in the sky for most of his life, he says he has been "really active" in observing for the last 10 years.

how to choose binoculars

Buying a pair of binoculars will be a bigger project than you think — if you want a good pair at a moderate price. The problem is that while there are lots of low-price models around, few will provide satisfactory performance.

Look at advertisements, both in ASTRONOMY and in your local newspapers. Since binoculars are carried by many types of stores — photo, department, and discount, to name a few — as well as by mail-order houses, you'll be wise to shop around.

To start with, let's dispose of some numerical mumbo-jumbo. Binoculars are "specified" in the following way: 6 x 35 ("six by thirty-five") means the binocular has main lenses with apertures of 35 millimeters and eyepieces that provide 6 power magnification. Similarly, a pair of 20 x 80s have 80 mm apertures and 20 power eyepieces.

For astronomical use, the larger the aperture the better, because you want as much light-gathering power as possible. To compare the relative light-grasp of two main lenses, compare the squares of their diameters. Thus, 7 x 50s collect twice as much light as a pair of 7 x 35s, and an 80 mm pair will collect 2.6 times as much light as a 50 mm pair.

When you start examining binoculars in the stores, you'll discover they come in two basic types. The conventional design has an offset or jog in the optical path between main lens and eyepiece. The so-called roof prism type is usually smaller and lighter for a given specification, and has an H-shape with a "straight-through" light path. In fact, both types send the light from the objective through pairs of prisms to place the lenses' natural inverted image right-side up because binoculars are intended for terrestrial use.

In practical terms, the roof-prism shape type will be well-made but expensive; virtually any pair will give you thoroughly satisfactory performance. The problems lie in finding a good conventional pair at a reasonable price.

Look for a careful finish, silky smooth focusing, and easy adjustments. Train the binoculars on an outside scene (ask to take them outside for the test — you can't tell anything by looking through plate glass) and see if the focus is crisp. Use a sunglint from car chrome as an artificial star. Does the image have colored edges, purple perhaps? If so, the pair is inferior in quality. Scan around while paying close attention to the image at the edges of the field of view — does it seem flat and undistorted? A poor lens will have a distorted field that seems to "hop" as you scan.

Remember that the more binoculars you look at, the easier it gets to spot the junk. Take lots of notes and never buy the first pair you see — at least not until you've made enough comparisons to satisfy yourself that it really is the best.

When you settle on a pair to buy, insist that the sale be conditional on your testing them on stars and get "sale subject to star-testing" marked on the receipt. (Check with the clerk before you pay.) Most stores will allow you to return an item provided it's in perfect condition. Even when you intend to buy a pair by mail-order, take the time to go from store to store and look over what they have. The experience will help you evaluate what you will get by mail. Reputable mail-order firms will allow returns under the same conditions as retail stores.

Above all, don't be afraid to be fussy! You'll use a good pair of binoculars for the rest of your life.

Take your binoculars and sweep south from Cygnus along the Milky Way. Here, near the "teapot" of Sagittarius and the star clouds of Scutum, lie some of the finest sights in the sky. The circles have 3° diameters; photo by Orien Ernest.

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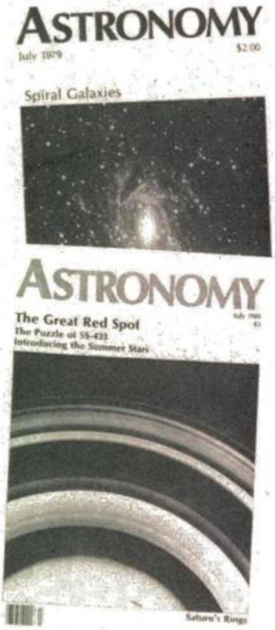
July 1981: "Mars: 5 Years after Viking;" "The Electronic Sky;" "July's Lunar and Solar Eclipses;" "The Age of the Universe"



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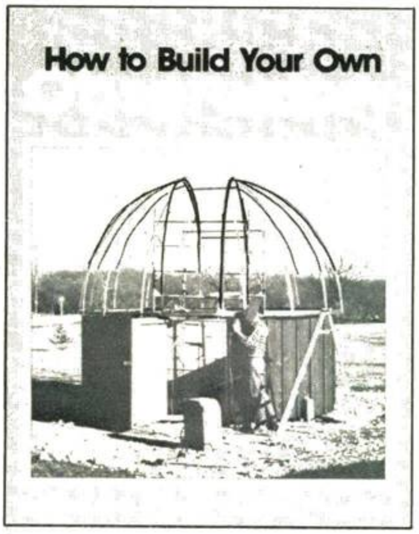
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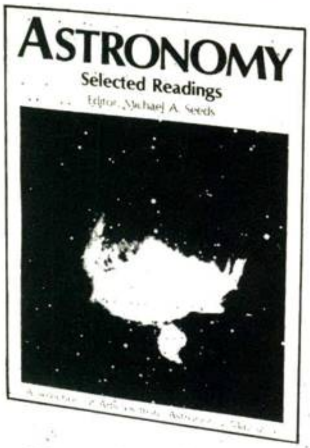
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afocal and projection astrophotography

photography in astronomy

Are you interested in obtaining your own sharp and detailed photos of the Moon and planets? Sure you are, but you've read some captions and the techniques sound pretty exotic. In fact, they're rather simple! Let's look at some camera and telescope astrophotography rigs from the "build 'em and use 'em" point of view.

Afocal Systems

"Afocal" is just a fancy name for the process whereby you take your camera — lens and all — and position it so that the lens looks squarely into the eyepiece. Work out the exposure, dial it in, and snap away....

Sounds a little too good to be true, doesn't it? Well, you're right — it isn't quite that easy. For one thing, although the system works well for the Moon and bright planets, it isn't very good on fainter stuff. Second, getting the telescope and camera precisely aligned for best results takes some practice.

But the system is basically simple. The three things you need are your telescope, a camera, and a good photo-tripod. Any camera will do — provided you can set exposure times and adjust the focus and f/stop — but your tripod should be sturdy.

Take your telescope outside and set it up where the ground is firm. If the mounting is an equatorial, align it on the pole and turn on the drive.

Let's say it's evening and the Moon is near First Quarter. Haul out your trusty 6-inch f/8 Newtonian, put a 28 mm eyepiece in the focuser and your SLR camera with its 55 mm lens is ready to go. First, aim the scope at the Moon and focus the eyepiece. Then take your camera and set the lens at the widest f/stop (f/1.8, let's say) and the focus at infinity.

Hold the camera up to the eyepiece, keeping the lens square-on to the eyepiece. You'll see an image in the viewfinder that looks dim over all and dark at the corners. Check on the ground-glass part of your focusing screen to see if the image is sharp, and if it isn't, adjust the telescope's focus.

If you don't have an SLR, set the camera's focus and aperture as above. Then take the finder scope off of your telescope, point it at the sky, and focus it on the Moon or a star. Next, aim the finder directly into the eyepiece and, while looking through the finder, adjust the main scope's focus until the image is sharp. (The finder then becomes a microscope to examine the telescope's focus.) Now position your camera to look straight into the eyepiece and take the photo.

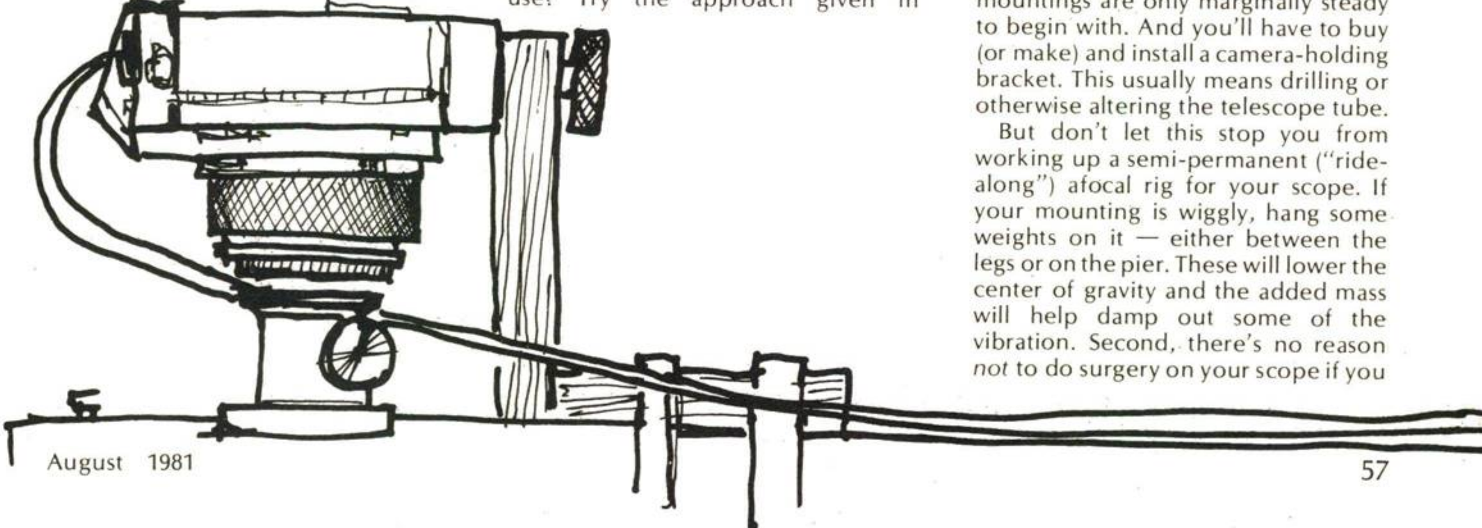
What exposure time should you use? Try the approach given in "Getting the Correct Exposure," ASTRONOMY, June 1981. The f/ratio for the system described above works out to be f/16. Let's assume 400 ASA film, a B value of 40, and crank all these numbers through the exposure formula. The result: 1/60 second exposure time.

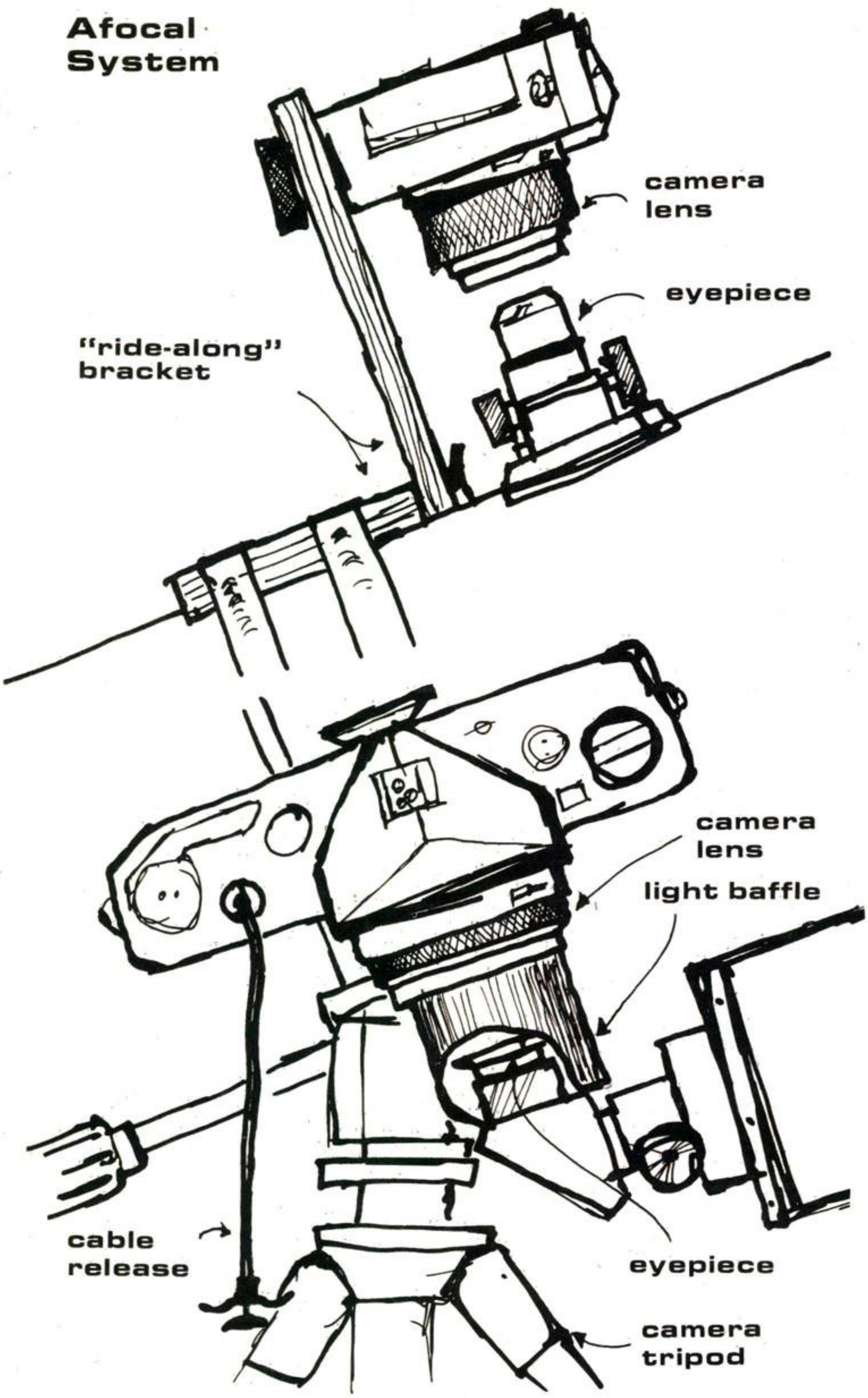
This procedure will work pretty well when you have fast film, a bright object, and a fairly low f/ratio telescope because exposure times will be short enough for you to hand-hold the camera. But if you want really sharp photos or greater magnification, support the camera on a tripod.

You'll soon find that smoothly coordinating a tripod-mounted camera and the eyepiece end of the telescope will call upon manual dexterities you never knew you had. But stay with it, because a tripod lets you use exposures up to a quarter second or a half second — exposures you'll need for detailed high magnification photos.

At some point, it may occur to you that life would be altogether easier if the camera and lens rode *on* the telescope. It would indeed, but don't lose sight of two matters. The added weight of camera-and-lens high above the ground will create some balance problems — and many telescope mountings are only marginally steady to begin with. And you'll have to buy (or make) and install a camera-holding bracket. This usually means drilling or otherwise altering the telescope tube.

But don't let this stop you from working up a semi-permanent ("ride-along") afocal rig for your scope. If your mounting is wiggly, hang some weights on it — either between the legs or on the pier. These will lower the center of gravity and the added mass will help damp out some of the vibration. Second, there's no reason *not* to do surgery on your scope if you





Afocal System

want to — just make sure you know exactly what you're doing before you chop and drill!

Whether your afocal system is hand-held, tripod-mounted, or ride-along, you'll need to make a light baffle to bridge the gap between camera lens and eyepiece. Without one, stray light will leak in to lower contrast or fog the exposure. Roll a piece of black construction paper into a tube fat enough to wrap around the lens and long enough to reach over the eyepiece. A piece of cardboard tubing the right size and painted black inside will make a sturdier and more permanent model.

Telescope "Lenses"

Another method in common use is the telescope-as-lens, or "prime focus" system. This method provides you with a very long telephoto lens, is simple to use, and is the usual choice of deep-sky astrophotographers.

Most of the nebulae, galaxies, and star clusters in the sky have small angular sizes; they would seem like natural candidates for enlargement — via the afocal process, for example. But because these objects are also extremely dim, the high f/ratios of the afocal and other projection methods force you to use the relatively low f/ratio at prime focus and do the enlarging in your darkroom.

To set up, you need an SLR camera and an adaptor that couples the camera body to the standard 1¼" inside diameter eyepiece holder. These are available from several different equipment manufacturers; try Edmund, S & S Optika, Meade, or Celestron.

A good adaptor should fit snugly in the eyepiece holder and have matt-black interior finish to minimize reflections and stray light.

Try any of the following remedies if yours isn't perfect. If the adaptor doesn't fit the eyepiece holder snugly, the camera will slip, slide, spin around — in short, drive you nuts. "Fatten up" a sub-sized connector with a short piece or two of masking tape. This will tighten a loose and sloppy fit. (Replace the tape every now and then.)

If the finish on the inside of the adaptor isn't matt-black, you'll get reflected light damaging each frame. To kill the reflections, line the light path with flocked paper (matt-black on one side and adhesive on the other) — Edmund sells it. Even flat black enamel like Testors, Pactra, or Floquil from a hobby store will help a lot.

When you use the adaptor, the telescope becomes the camera lens. Focus by looking into the camera viewfinder and adjusting until the image is sharp. Since most camera focus screens are designed to work with fast lenses, your f/5 (or slower) telescope will "black-out" the central split-image or micro-prism dot. Focus on the ground-glass ring surrounding it.

Rack the eyepiece holder in and out of focus, decreasing the overshoot until you are right on target. Critically re-focus after each shot because mirror-slap or shutter-shake can jar things out of adjustment if they are even slightly loose.

To eliminate shutter-shake, use the trusty "hat trick": focus on your subject, set the camera shutter to B or T, cover the front of the telescope tube with your "hat" (a sheet of black construction paper or cardboard painted flat black), and open the shutter.

After vibrations from the whap-bang of the mirror and shutter mechanism have had five seconds or so to die down, uncover the telescope tube to start your exposure. To finish, recover the tube and close the shutter. A practiced flick of the wrist can make exposures as short as 1/10 second this way.

How long you can expose depends on how good your scope's clock drive is. For most bright objects, exposures last no more than a few seconds — no problem there. Many drives will even let you record (on fast film) objects like the Orion Nebula, the Pleiades, or some of M-31 in exposures that run from 30 seconds to five minutes. (For exposures exceeding a few minutes, you'll have to guide the telescope — a topic we'll discuss later.)

Eyepiece Projection

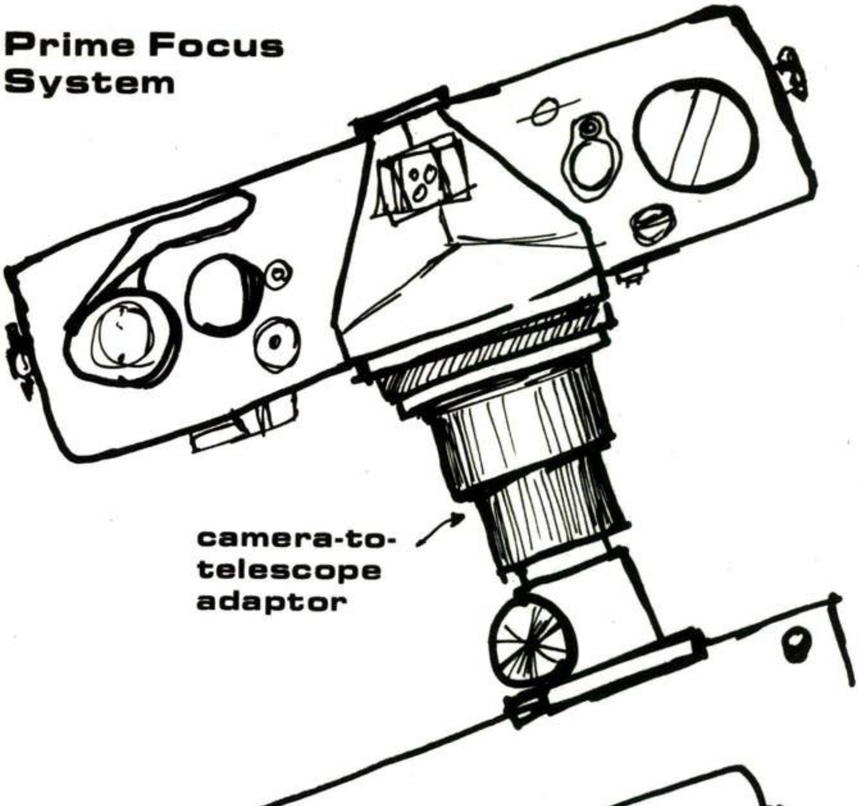
An embellishment on the telescope-as-lens method, eyepiece projection uses an eyepiece inside the adaptor to throw a magnified image from the telescope optics onto film in the camera body.

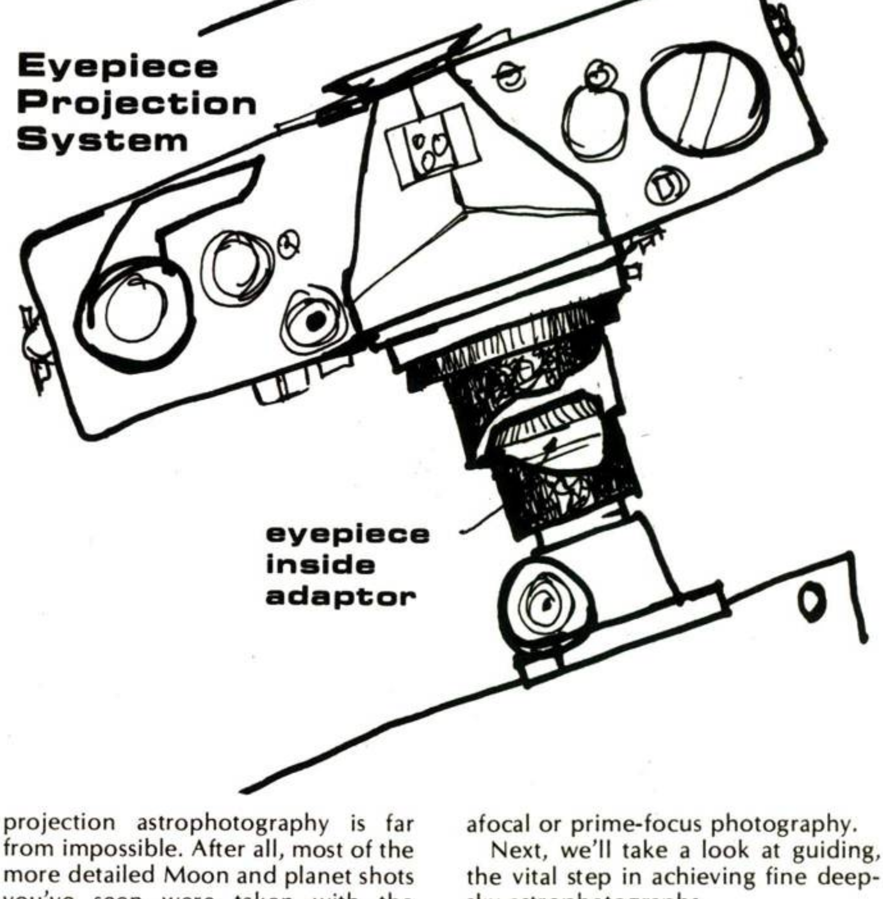
Either positive lenses (eyepieces) or negative ones (Barlows) will work, although good eyepieces are generally the most satisfactory. Those in the 18 to 28 millimeter range often work out well. The best lunar and planetary shots are usually taken with focal ratios between f/40 and f/100, which calls for magnifying the original telescope image a lot — up to as much as 20x.

In theory, there's no limit to magnification. But in practice, seeing, image brightness, and technique limit what you can get. In a 6-inch f/8 telescope working at 6x magnification, 3 seconds of arc (mediocre seeing) measures about 0.1 mm across on film. Negatives with resolutions like that aren't going to enlarge very well. (The best photos are taken in those rare and extraordinary moments when seeing becomes 1 second of arc or better.)

Additionally, dim objects can demand impossibly long exposure times. For example, trying to photograph a galaxy using eyepiece projection with the 6-inch system mentioned above would call for an exposure of 160 hours — not even allowing for reciprocity failure!

Lastly, at high magnifications, every little glitch and hickey in your technique will be glaringly obvious. You have to get the telescope free of vibration, the image sharply focused, the exposure and film both right, and a good projection eyepiece in place — all at the exact moment when seeing suddenly gets good. *Everything* has to be right: no goofs, no slip-ups.





Despite its hitches, eyepiece projection astrophotography is far from impossible. After all, most of the more detailed Moon and planet shots you've seen were taken with the method. But be ready to use a lot of film. And — because it demands skill and refuses to yield good results with less-than-perfect skills — don't start your sky-shooting with eyepiece projection: work up to it through afocal or prime-focus photography.

Next, we'll take a look at guiding, the vital step in achieving fine deep-sky astrophotographs.

— *Robert Burnham*

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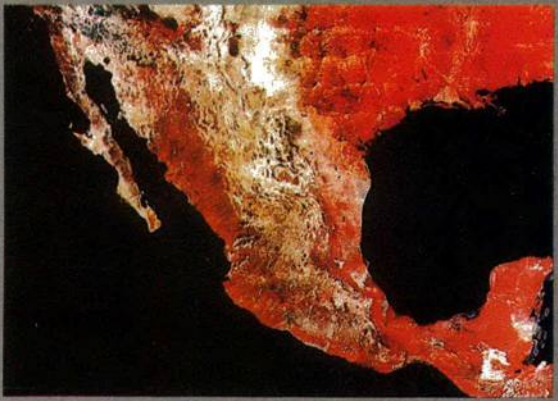

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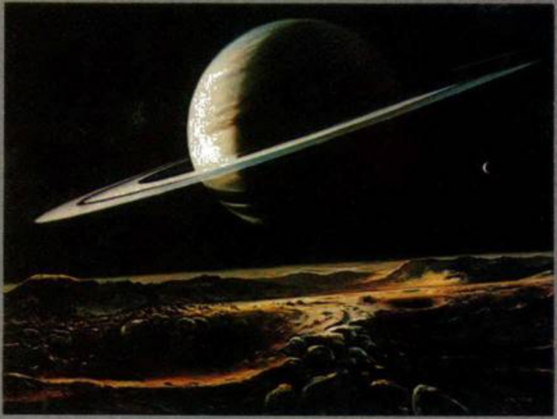

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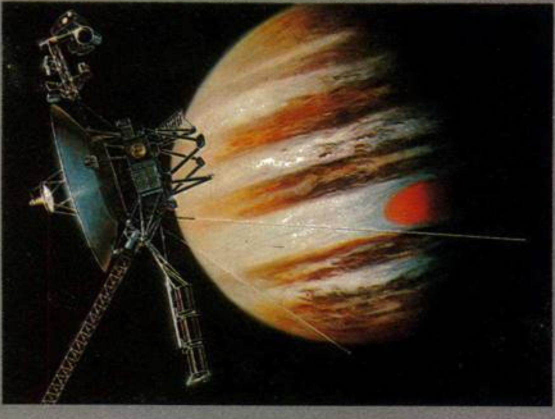

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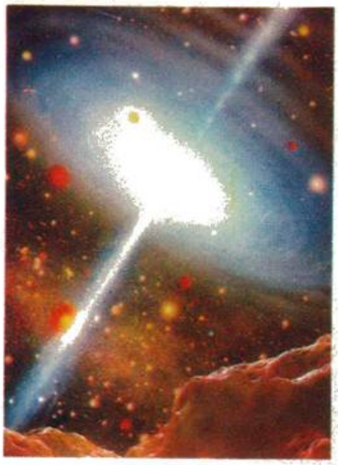

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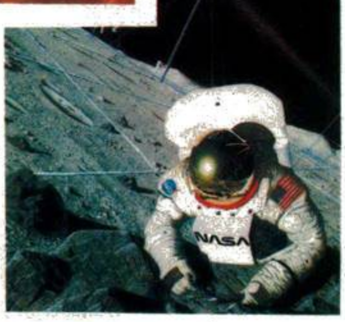

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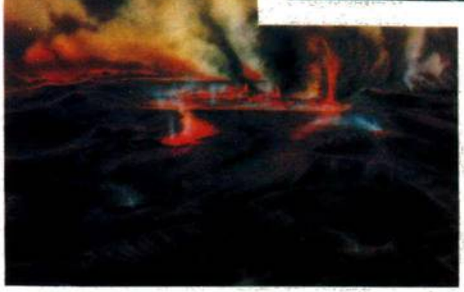

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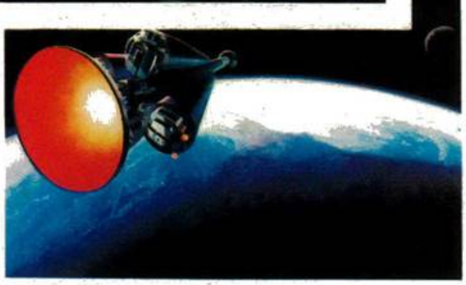

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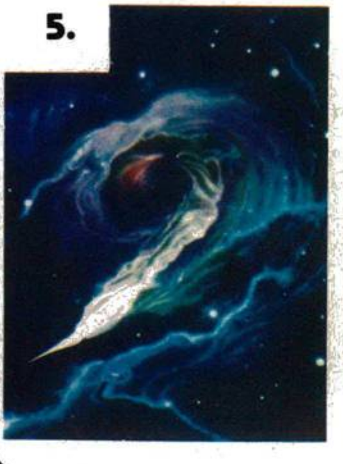

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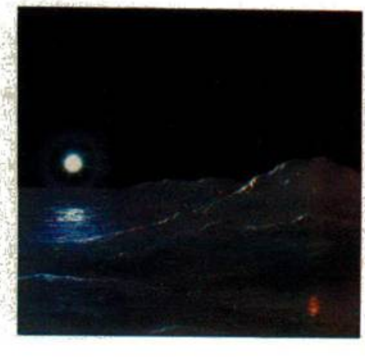


AstroNews

NASA Schedules First Shuttle Payload

NASA scientists and engineers are making preparations at Kennedy Space Center, Florida, to install the first payload to be carried into space aboard the Shuttle *Columbia* during STS-2 (its second test flight), now scheduled for September 30.

The payload is called OSTA-1 for NASA's Office of Space and Terrestrial Applications, which is providing most of the seven experiments. Designed to demonstrate the shuttle's capability for scientific and applications research, the experiments are concerned primarily with remote sensing of land resources, atmospheric phenomena, and ocean conditions.

The experiments include an imaging radar (Shuttle Imaging Radar, or SIR-A) to help test advanced techniques of mapping for oil and gas exploration; a multispectral infrared radiometer (SMIRR) to measure the solar reflectance of mineral-bearing rock formations; and a feature recognition system (Feature Identification and Location Experiment, or FILE) designed to discriminate between water, bare ground, vegetation, snow or clouds and thus control sensors to collect only "wanted" data.

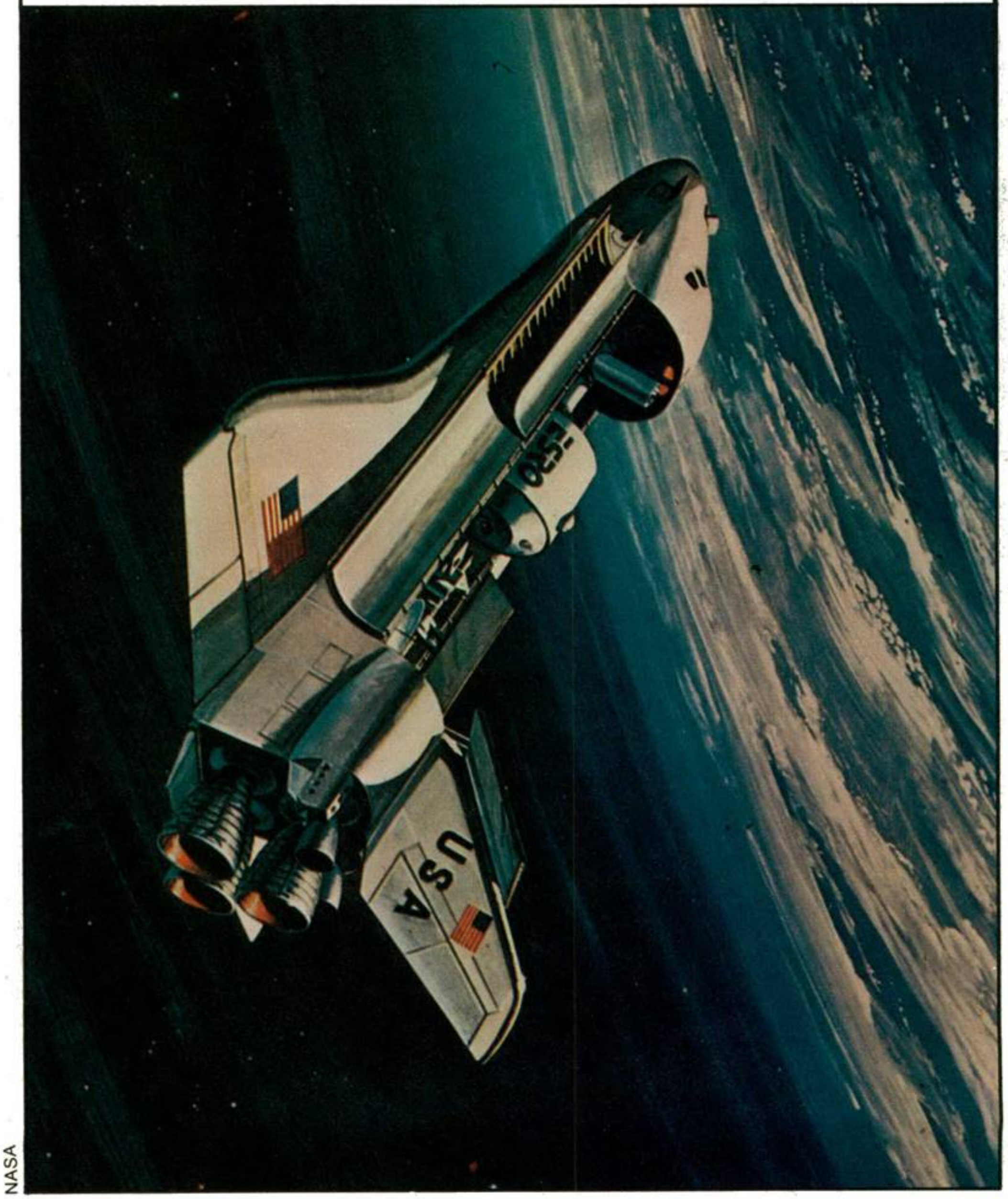
Additional experiments include one on air pollution (Measurement of Air Pollution from Satellites, or MAPS), designed to measure the distribution of carbon monoxide in the middle and upper troposphere (12 to 18 kilometers altitude); an ocean color scanner (Ocean Color Experiment, or OCE) to map algae concentrations which may indicate feeding areas for schools of fish or pinpoint possible pollution problems; a night and day optical survey of lightning storms (NOSL); and a biological engineering experiment (Heflex Bioengineering Test, or HBT) to determine the relationship between plant growth and moisture content in the near weightlessness of space.

The air pollution and feature recognition experiments operate continuously for the whole mission with the imaging radar, radiometer and ocean experiments taking data over pre-selected sites. The lightning experiment is a "target of opportunity" instrument. All the experiments can be run from the ground control center or by the astronaut crew using the shuttle's general purpose computer.

All the OSTA-1 scientific data will be recorded onboard on tape and film and will be removed from the shuttle on landing and turned over to the experimenters for immediate screening and analysis. The instruments themselves will be removed from *Columbia* after it is ferried to the Kennedy Space Center.

The second shuttle flight will be launched from the Kennedy Space Center into a 280-km circular orbit with an inclination of 40.3°. When the 4-day mission is over, the shuttle will land at Edwards Air Force Base, California.

The Shuttle will carry a wide range of payloads into orbit.



NASA

HEAO-2 Ends Mission

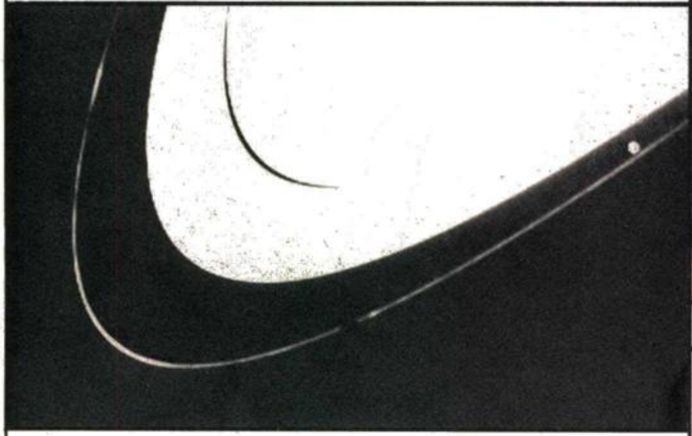
NASA's second High Energy Astronomy Observatory (HEAO-2) has exhausted its control gas supply, thus ending its flight mission.

HEAO-2 is one of a family of three highly successful scientific satellites. With two years and five months of operations, HEAO-2 (like its predecessor, HEAO-1) performed more than twice as long as its design called for — a feat expected to be equaled by HEAO-3, still in operation.

HEAO-2 was launched November 13, 1978. It carried the world's largest focusing X-ray telescope and an array of imaging and analyzing astronomy instruments. During its long lifetime, it performed thousands of studies of X-ray emitting stars, supernova remnants, galaxies and quasars.

Although it will take years for participating astronomers to analyze completely all the data they received, important discoveries have already been made concerning the X-ray output of normal stars, the composition of supernova remnants, the distribution of mass in galaxies and clusters of galaxies, and the origin of the extragalactic X-ray background.

The spacecraft was operating extremely well when it used up the last of its reaction control gas April 25 and could no longer aim itself. Spacecraft and instrument engineering tests were performed until the onboard batteries ran out and, on a later orbit the following morning (when the solar panels were in sunlight), all systems were switched off. Re-entry and burn-up are expected next year.



NASA photo

The F ring lies just outside the A ring and is flanked by two "sheepdog" satellites.

New Theory on Braided Ring

Saturn's braided F-ring was the most stunning discovery of last year's Voyager 1 Saturn flyby. According to known laws of celestial mechanics it shouldn't exist — but it does.

Dr. Stanley Dermott of Cornell University has now advanced an explanation, one within the known laws of nature. In the April 9, 1981 issue of *Nature*, Dermott suggests the F-ring is not braided, it just looks that way because of a bizarre resonance effect.

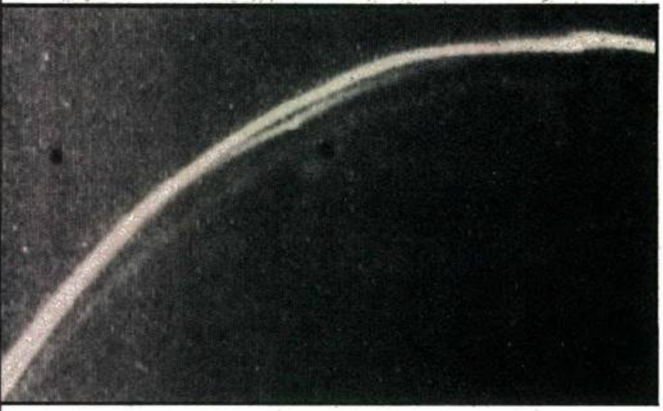
Two tiny "sheepdog satellites" orbit just outward and just inward of the F-ring and hold it together with their gravitational influence. They also exert tidal torques on the ring's particles and generate two separate standing waves. The interaction of these waves, Dermott suggests, produces "beats" in the F-ring.

If the ring's circumference is an exact number of "beats," a resonance effect occurs, and Dermott says that's what is happening. The outer and larger sheepdog, S-13, creates what Dermott calls "a first-order resonance" in the ring. It "excites a wave pattern of equally-spaced loops which co-rotate with the perturbing satellite."

Waves on opposite sides of the resonance have a 180 degree phase difference, causing the ring's braided appearance. Other short-term perturbations send shock waves through the ring and cause the formation of particle clumps, also seen in the Voyager photos.

A third barely visible braid is not accounted for by this process. Dermott himself thinks it is made of particles eroded off other ring particles and removed by electromagnetic forces. Why the third braid exists, and why it is not part of the other two, still awaits explanation.

Three "strands" make up the braided F ring.



NASA photo

"Lost" Asteroids Found

Two minor planets discovered decades ago and then "lost" have been located again with the help of the Indiana University astronomy department's minor planet center.

Asteroid (452) Hamiltonia was discovered on December 6, 1899 at Lick Observatory, Mount Hamilton, California. It was not identified again until 1973 when it was observed by the Crimean Astrophysical Observatory in the Soviet Union on two consecutive nights.

On the basis of these three observations, astronomers were able to identify it as the same object seen by Indiana University's Goethe Link Observatory on January 19, 1958, thus confirming the asteroid's rediscovery. The 1958 Indiana observation is the only one known between 1899 and 1973.

Asteroid (1537) Transylvania was discovered at the Budapest Observatory in Hungary on August 27, 1940, but the discovery plates were apparently lost or destroyed during World War II. Recently, astronomer L. K. Kristensen of the University of Aarhus (Denmark) suggested that an object seen by the Goethe Link Observatory on December 30, 1962 might be 1537 Transylvania.

This identification has now been confirmed, according to Brian Marsden, director of the International Astronomical Union's Minor Planet Center, Cambridge, Massachusetts.

"I want you to know how crucial the pair of Indiana 1962 observations were for this," Marsden wrote to Delores Owings, a research assistant at the Indiana center.

Accurate positions of asteroids are measured on photographic plates in Indiana University's archival collection by Owings and a small group of work/study students in response to specific requests from astronomers who are working on problems concerning asteroid orbits.

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AstroNews

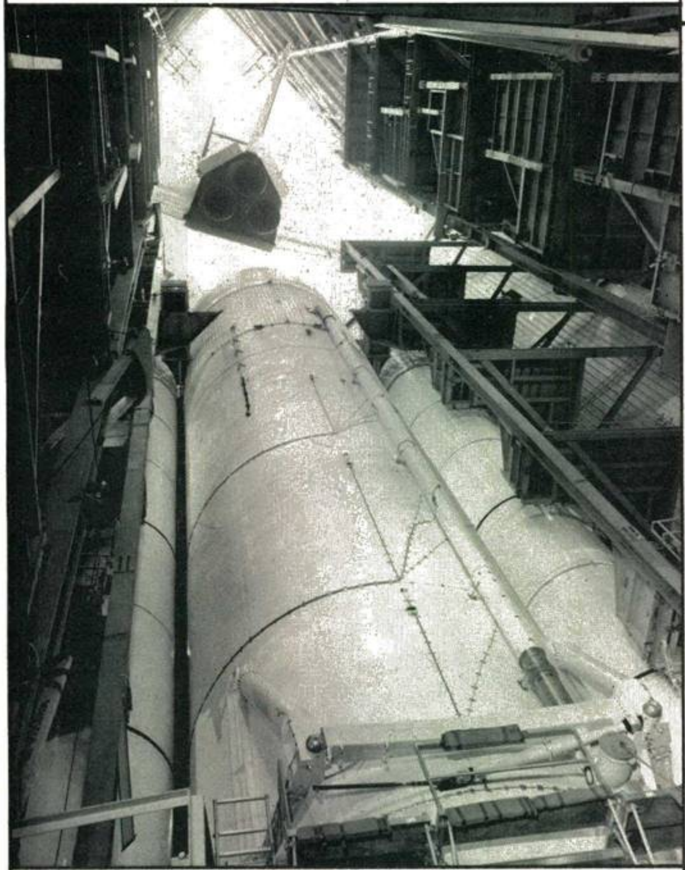
Second Shuttle Launch Set

Now that NASA officials have assessed the results of the first Space Shuttle flight, a target date for *Columbia's* second launch has been set for September 30, 1981.

The officials emphasize, however, that this date assumes no problems in the "turn around" for the *Columbia* — and they point out that since this is the first time the process has ever been done, unforeseen problems could still delay the launch.

The *Columbia* returned to the Kennedy Space Center, Florida on April 28, 1981 following its highly successful first mission, completed on April 14.

Years of testing preceded the first flight of Columbia. *Here* Enterprise *is mated to two boosters and the external tank.*



NASA photo

Stellar Eclipses Observed

For the first time, astronomers have observed the coronal eclipses of a pair of stars similar to the Sun.

The subject of the recent observations are the stars in the binary system AR Lacertae. The stars are 1.8 and 3.1 times as large as the Sun, about 30% more massive, and are slightly older. However, they are relatively similar to the Sun.

The eclipse of one star by the other (and the reverse a half cycle later) allowed David M. Gibson of the New Mexico Institute of Mining and Technology and Frederick Walter of the University of California to study both stars' coronae.

"Eclipses are really the best way we can study the size, mass, and structure of other stars. They allow very direct measurements and provide unambiguous results," Gibson says. Previously, coronal sizes had to be estimated by computer models.

Although stellar eclipses have been observed before with optical telescopes, Gibson and Walter used the Einstein X-ray satellite to record the coronal eclipse because the 6 to 50 million-degree gases emit most of their radiation at those wavelengths.

The satellite recorded the eclipses in June 1980, but the information was not available for analysis until January 1981. Therefore, Gibson and Walter have not yet had an opportunity to analyze and interpret it fully. In their preliminary analysis, the researchers estimated the size of the corona around the smaller star to be about 15% of its radius. The corona of the larger star may be larger still.

They also noted that during the eclipses, the X-ray emissions changed slowly and steadily rather than abruptly. The scientists say they believe this means the coronae of the stars are composed of many loop structures. The loops are hotter and denser than other parts of the atmosphere.

The Einstein satellite has been plagued with mechanical problems for several months and is no longer functioning. As a result, Gibson says he and Walter will have to use other means for future studies of this star system because another X-ray satellite will probably not be launched for many years.

Quasar Eruptions Plotted

Radio astronomers at the California Institute of Technology have produced the first detailed radio maps showing an immense blob of matter erupting away from a quasar at nearly the speed of light. The maps offer the strongest evidence so far about how a remarkable celestial phenomenon called *superluminal expansion* works.

The Caltech researchers published their results in the April 2, 1981 issue of *Nature*, a British scientific journal. Timothy J. Pearson, Stephen C. Unwin, Marshall H. Cohen, Roger P. Linfield, Anthony C. S. Readhead, George A. Seielstad, Richard S. Simon, and R. Craig Walker made up the research team.

Over a decade ago, astronomers discovered that certain quasars appeared to have blobs of matter expanding away from them at faster-than-light speeds. Of course, such speeds are theoretically impossible, and researchers sought to explain the phenomenon in more scientifically acceptable ways. One such explanation was that quasars, incredibly violent objects at the edge of the universe, are emitting intense beams of high-energy matter, and that blobs of this matter erupt periodically from the quasars at nearly the speed of light. If this eruption is aimed at Earth, a time-delay phenomenon could make it appear that the object is leaving the quasar at faster-than-light speeds.

Other explanations contended that, rather than erupting blobs, the superluminal phenomenon was produced by an expanding shell of gas or by a succession of explosions moving outward from the quasar — like the succession of blinking lights on a Christmas tree. Other models held that astronomers simply had the distances wrong, and that quasars were much closer to Earth. The speeds of expansion would then actually be much lower.

The five Caltech maps — all of quasar 3C-273, about 2.5 billion light-years from Earth — were made between 1977 and 1980 and have for the first time clearly shown a large blob of matter steadily moving away from the quasar. The blob is part of a jet of matter and energy more than a million light-years long.

The radio maps were made using the technique known as very long baseline interferometry (VLBI), in which two or more widely separated radio telescopes are simultaneously trained on a celestial object. (See "Using the Earth as a Radio Telescope," ASTRONOMY, October 1979.) When the observations are combined, the effect is as if one gigantic radio telescope has been used. Thus, radio astronomers can resolve objects a few light-years across at distances of billions of light-years. The Caltech researchers used radio dishes in Germany, Massachusetts, West Virginia, Texas and California for their observations.

The latest maps of 3C-273 are a great improvement over those made from previous observations because more radio antennas were used in the studies and improved techniques allowed better clarity.

"We hope to do further observations to follow the blob as it moves away from the quasar," said Dr. Pearson. "However, in order to resolve the continuous stream of matter erupting from the quasar and to see a succession of blobs that grow fainter as they go, we will need a much better VLBI network, such as a national array."

A Caltech study group has recently recommended that the U.S. build a nationwide array of radio telescopes, stretching from Massachusetts to Hawaii and north to Alaska, that would, in effect, transform the entire U.S. into one gigantic radio telescope. With such an array, such mysterious objects as quasars and exploding galaxies could be mapped in fine detail.

The quasar 3C-273, the brightest quasar we know, is one of four now known to exhibit superluminal expansion. It is historically important because it was the first one recognized to be at the edge of the observable universe. Caltech astronomer Maarten Schmidt did this in 1962. It was also the first quasar in which superluminal expansion was detected — in 1969 — by another Caltech astronomer, Marshall Cohen.

Diamonds Found in Meteorite

Tiny crystals of diamond, formed in an ancient cosmic catastrophe, have recently been found in a 10.4 kilogram iron meteorite collected from the Antarctic ice cap in 1977. The discovery was reported in *Nature* by Roy S. Clarke Jr., Daniel E. Appleman and Daphne E. Ross, all of the Smithsonian Institution's National Museum of Natural History.

This is the first iron-type meteorite since the Canyon Diablo (which created the mile wide 50,000-year-old meteor crater in Arizona) that has been found to contain diamonds.

Scientists believe the diamonds in the Canyon Diablo meteorite were produced as a result of the shock pressure created by its impact with Earth. The Antarctic meteorite is much smaller and would not have produced a sufficient shock when it impacted — therefore its diamonds must have been produced in space.

Researchers found the diamonds, a type of carbon formed at high pressures, as invisible crystals in small carbon-rich fragments inside the nickel-iron metal that makes up the meteorite. They were discovered when a saw used to slice the meteorite came up against one of the diamond-bearing inclusions and refused to cut any farther.

X-ray studies then revealed the presence of diamond, together with two other forms of carbon: a rare mineral called lonsdaleite (chemically identical to a diamond but with a different crystal structure) and graphite, the familiar form of carbon used in pencils.

The tiny amounts of diamond found by Dr. Clarke and his colleagues have no commercial value. The meteorite is probably a fragment of an asteroid, and the diamonds in it bear witness to a great collision that probably took place in the asteroid belt many millions of years ago.

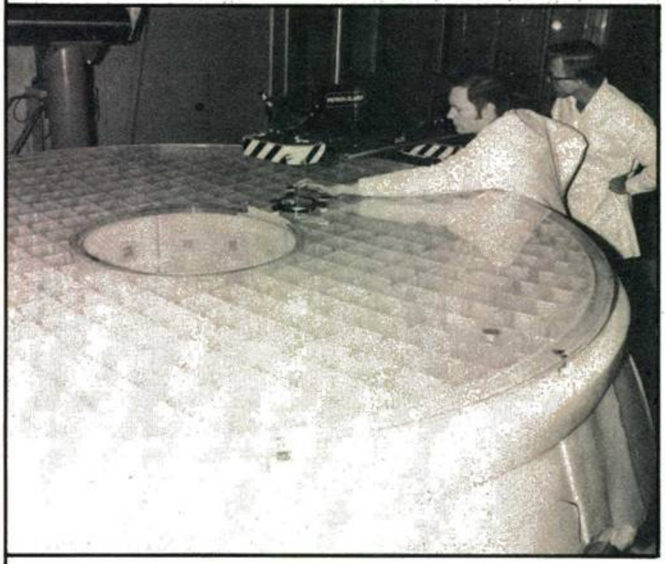
Diamonds only form at high pressures and for small objects like meteorites, such pressures can be supplied only by the intense shock waves that result when asteroids collide with each other —or with the Earth — at speeds of tens of thousands of miles an hour.

Diamonds found in the Canyon Diablo meteorite occur in the same way — as tiny crystals in carbon-rich inclusions in the metal, but, unlike the new find, that meteorite had enough mass to cause the impact needed to create the crystals.

"The diamonds in the Canyon Diablo meteorite seem to have formed when it hit the Earth and made Meteor Crater," explained Dr. Clarke. "The shock waves produced by the impact converted natural carbon (graphite) in the meteorite to diamond. But the Antarctic meteorite is too small to have formed a crater. Because it is small, it would have been slowed down as it came through the atmosphere and hit the ice at a low speed. Therefore any diamonds in it must have formed before then, probably as the result of two asteroids colliding. This meteorite is a fragment from the collision."

The diamond-bearing meteorite was collected in 1977 from the Allan Hills region of Antarctica, where more than a thousand new meteorite specimens have been found since 1976. Only nine of these are the iron type; the remainder are various kinds of stony meteorites.

Some of the special meteorites found in the Antarctic include an extremely well-preserved carbon-rich specimen, a new family of stony meteorites, another puzzling stone that seems almost 3 billion years younger than other meteorites, and one that was preserved in the Antarctic ice for almost a million and a half years.



NASA photo

Opticians at Perkin-Elmer pose beside the huge 1/20-wave primary of the Space Telescope.

Space Telescope Progressing

The shaping and polishing of the 2.4-meter primary mirror for NASA's Space Telescope has been completed according to NASA officials.

The mirror's surface has a figure that deviates less than one-millionth of an inch from the ideal shape. The primary mirror is the major optical component of the Optical Telescope Assembly (OTA), a major element of the Space Telescope.

The 10-ton unmanned telescope will be placed in Earth orbit in early 1985 by the Space Shuttle and will have a mean orbital distance of 500 kilometers, putting it well above the interfering haze of Earth's atmosphere. It will enable astronomers to gaze seven times farther into space than now possible and to observe a volume of space some 350 times larger than presently seen.

The Space Telescope is of an optical design known as the Ritchey-Chretien Cassegrain, a folded system with a secondary mirror in front of the primary mirror and the image plane behind the primary mirror.

Manufacture of the primary mirror blank began in October 1977 and the blank was ready for grinding a little over a year later, in December 1978. The first step was a rough grinding of the front and back surfaces and of the inside and outside edges of the mirror shape. Fine polishing of the mirror's front surface, using a specially developed computer controlled polisher, began in August 1980.

The next stage of fabrication will apply two extremely thin, uniform coatings to the mirror's polished surface. First, a reflective layer of pure aluminum 1/50,000" thick will be applied and then a protective layer of magnesium fluoride 1/167,000" thick which will prevent the aluminum from oxidizing until it reaches the vacuum of space.

After it is coated, the mirror will be installed in the OTA and aligned to the secondary mirror, focal plane, and scientific instruments, which include fine guidance sensors and optical control sensors. The completed OTA will then be integrated into the Support Systems Module, another major element of the Space Telescope, and tested in its final configuration for flight.

ASTRONOMY
REVIEWS

Bound for the Stars

Saul and Benjamin Adelman
335 pages, hardcover, $17.95; paper, $8.95
Prentice-Hall (1981)

Bound for the Stars is an optimistic volume. The authors — a father and son team — clearly believe that the "social, economic and technical forces" needed to expand mankind's habitat into space are present today. They describe the research that is taking place now and speculate on how that research could be translated into commercial enterprises and further scientific research in space.

While the Adelmans advocate an aggressive space program that will eventually lead the human race to the stars, they don't ignore their critics. For example, they state that it is vital for space transportation costs to be greatly reduced if space activities are to be practical, and they detail how this could be carried out in the coming decades. Then the authors point out that some credible sources believe that space transport costs cannot be significantly lessened in the foreseeable future. Although the authors present their own arguments with greater detail and vigor, the fact that they present the other side of various issues at all is a major strength.

Despite the book's primary concern with the future, the authors take an occasional glance at the past and offer some insights on the early days of the American space effort. For example, their examination of the nuclear rocket projects, which were overshadowed by the spectacular successes of Gemini and Apollo, is particularly interesting.

Much of the book is spent speculating in detail about the technologies needed for an interstellar flight, what provisions would be needed and what it might be like to take part in such an adventure.

In their description of an imaginary flight to Alpha Centauri (and in later sections concerning commercial Moon shuttles and a manned Mars mission), the authors use a "you are there" narrative technique. They lead the reader through the choice of a propulsion system (catalytic nuclear ramjet), discussions of crew selection, and even a description of how Earth will communicate with the starship crew. They stress that the closed life support system must be nearly 100% efficient and just about flawless if the travelers are to survive the multi-year journey.

The authors recognize that if such a voyage is ever to become a reality, there must be great changes in the direction of the space program. They offer a number of long range plans for space exploration, each of which would eventually lead to the exploration and colonization of the stars.

The Adelmans are also critical of the way NASA and its projects are funded. As an alternative, they suggest a funding scheme based on the European Space Agency format, where future space programs would be shared among a number of willing nations. They go so far as to call for a "Free World Space Consortium" to be made up of countries that already boast their own space programs.

The authors adeptly handle the problem of making technical subjects easy to understand yet not too bland for those with some knowledge of the subject. They explain topics (such as rocket propulsion) accurately and well, but not to the extent that a non-technical reader would be bored.

If *Bound for the Stars* has a single important fault, it is that the book includes too much. For this reason, it occasionally seems somewhat undirected.

The book's stated purpose is to explain the various aspects of space exploration and how, one day, the human race may reach the stars. Yet in the first chapter, the authors discuss how life started on Earth, how it might evolve elsewhere in the universe and how we might detect it.

The second chapter is titled "Survey of the Solar System," and is just that, a superficial outline of the major components of our planetary system. Such digressions, and there are a few others, only distract the reader from the book's theme.

But all faults aside, *Bound for the Stars* is an informative and entertaining volume. A good primer on the subject of space exploration, the book's optimism and logic make the whole adventure all seem quite possible. *Robert G. Nichols.*

Plossl Eyepiece Set

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"An eyepiece is an eyepiece — why spend any more than you have to on them?" said a friend of mine when I mentioned I had just purchased a set of Tele-Vue eyepieces. Certainly at $55 each, the price is enough to make anyone stop and think twice. But I am satisfied because the Tele-Vue Plossls are the sharpest I've ever used.

For years I've gotten along with a pretty ratty set of eyepieces, some that I bought 20 years ago, some that came with various telescopes, and a big Erfle I bought a few years ago. I've looked at, and been tempted by, newer ones, but whenever I've compared them at ATM meetings, I haven't seen any that gave sharper images than those I already own.

The Plossls arrived looking beautiful. Nothing was loose; nothing rattled or shook. They were extremely clean and dust-free. For a quick check, I tried all four in my Astroscan — then I knew I had something good! Even with the f/4.5 optical system of the Astroscan, the images were crisp and sharp nearly to the edges of the field. When I focused, the image seemed to "snap" at the moment of best focus instead of mushing through focus as do many eyepieces used on a fast optical system.

I frequently use the Astroscan for projecting the solar image. My trusty old 28mm Kellner eyepiece does a terrible job — the image is mushy and has color fringes. The 28mm RKE is a vast improvement — but it still is a bit soft through focus and some detail is lost. The 26mm Plossl does a superb job — tiny low-contrast details in sunspot penumbrae stand out sharply.

Used with my 12" f/7 telescope, the Plossls deliver crisp images of the planets. I have the distinct impression that the eyepiece adds no optical errors to the image I'm viewing, and that I am seeing everything the mirror can deliver. This is an impression I've never had with any other eyepiece.

Tele-Vue's Plossls also look handsome. They are quite heavy, feel solid, and possess details of fine workmanship. Their shape fits my eye quite comfortably. Although the 26mm can be used with glasses on, I must remove mine to use the others. Without glasses on, I must refocus slightly when I switch from one eyepiece to another. One slight note of caution: the barrels of these eyepieces are *exactly* 1.250" in diameter. Since one focuser I own is undersize by several thousandths of an inch, the Plossls do not fit it properly. If you buy these eyepieces, you may also have to upgrade your focuser.

Are these eyepieces worth their price? If you are using a slow optical system, most eyepieces will give you a satisfactory image. With fast optics, however, I haven't seen anything to match them. *Richard Berry.*

Tides and the Pull of the Moon
Francis E. Wylie
246 pages, hardcover, $12.95
Stephen Greene Press (1979)

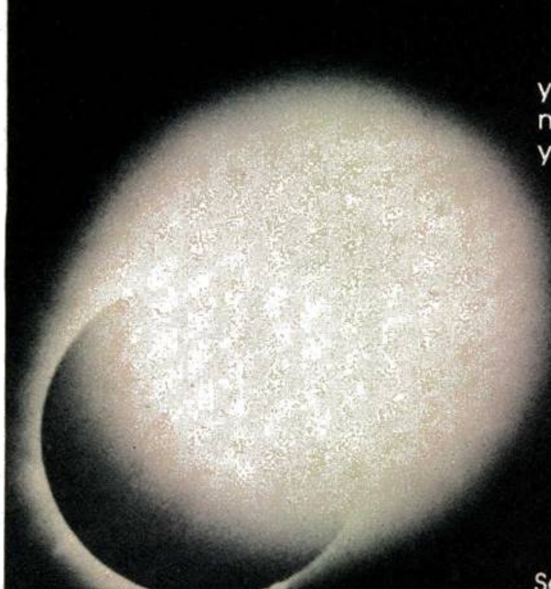
The Moon and the tides are two aspects of nature that have fascinated people everywhere from early times. Pliny called the Moon "the star of our life," and Aristotle was despondent over his failure to understand the tides. The physical connection between the two was recognized almost as soon as people from the nearly tide-free Mediterranean ventured beyond the Pillars of Hercules into the open Atlantic.

Tides are caused by the gravitational pull of the Moon and Sun; nearly everyone knows that they rise and fall roughly twice each day. Some, more observant, also see that the size of the tide varies from day to day. High tide is higher, and low tide lower, at New Moon and Full Moon than at other times in the cycle of lunar phases. But the exact relationship is quite complex, since it depends on such local factors as topography and weather.

Because of differences in the shape of the shore and the ocean bottom, the same tide that has less than two meters of amplitude at Philadelphia will vary by an awesome twelve meters in the Bay of Fundy, a few hundred kilometers to the northeast.

Violent storms can also create large and destructive tides, resulting in shoreline havoc. These variations, usually unpredictable, have often caused the tides to intervene in many human activities ranging from yacht racing to commerce to war. The date of D-Day, for example, was picked according to predictions of moonlight and tide.

But *Tides and the Pull of the Moon* is not simply a chronicle of good fortune



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and disaster bestowed by the ebb and flow of the oceans. The many aspects of tidal activity are presented in an mixture of physical explanation and anecdote.

Wylie writes about current scientific research on tidal mechanics, the reverse effect that terrestrial tides exert on the Moon's orbit, navigational problems, ideas for harnessing the tides for power, and the critically important ebb and flow cycle for estuarine animal life — and he does so in a style not overwhelmingly technical.

For some people, it comes as a revelation that the Moon exerts a physical influence over so many aspects of human lifestyles — far more direct and important, in fact, than any astrological fantasy supposes. Wylie succeeds in presenting a multi-faceted subject in a coherent and engrossing manner that can hold the interest of a bright high-schooler as readily as a professional scientist.

All books have flaws, of course. For example, readers ought to be warned that Fergus Wood's ideas on the symbiotic interaction between wind and tide are controversial among meteorologists. And contrary to the author's suggestion, there will be tides when the Moon has receded so far that the day and month are equal, because the Sun will still be raising the waters just as it does now. Wylie also contends that the tidal braking of Earth's rotation and the subsequent transfer of spin energy to the lunar orbit means that the Moon is speeding up, when in fact both the day and the month are getting longer. But these are minor quibbles.

The Moon, "the star of our life," and her tides are fascinating, and Francis Wylie does them justice. *J. Derral Mulholland.*

Stars for Lincoln, Doctors and Dogs
James Benbow Bullock
97 pages, paperback, $7.95
Gourmet Guides (1981)

By using the one asterism everyone knows — the Big Dipper — as a reference point, Bullock proceeds in a lighthearted way to teach the reader how to find all the bright constellations visible from mid-northern latitudes, and retells a lot of starlore in the process.

Discovering Relativity for Yourself
"...with some help from Sam Lilley"
425 pages, hardcover, $49.50;
paperback, $19.95
Cambridge University Press (1981)

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Thirty years ago (he says), Sam Lilley noticed that a lot of people have a hard time understanding what relativity is all about. Since he was a science teacher, he decided to develop a method of explaining the subject that would be understandable to the general layman. This volume is the book version of the superb relativity course he currently teaches.

Cosmic Dawn
Eric Chaisson
303 pages, hardcover, $14.95
Atlantic-Little, Brown (1981)

Chaisson, an astronomer at the Harvard-Smithsonian Center for Astrophysics, tells the story of the evolution of the universe from its beginning with the Big Bang. He assumes his reader has no special background in astronomy.

Interiors of the Planets
Alan H. Cook
348 pages, hardcover, $59.50
Cambridge University Press (1980)

Cook begins with the known dynamical properties of a planet and then reasons what they imply about interior structures. The approach is solidly mathematical.

Horizons
Michael A. Seeds
414 pages, paperback, no price given
Wadsworth Publishing (1981)

Horizons is one of many books that cater to the numerous astronomy-for-non-science-majors programs so popular in colleges and universities. It provides a good non-mathematical overview. The publishers have also produced a separate, 240 page "study and resource guide" by George Reed.

Space Science Comes of Age
Paul A. Hanle and Von Del Chamberlain, eds.
194 pages, hardcover, $22.50;
paperback, $12.50
Smithsonian Institution Press (1981)

In 11 chapters by 11 authors, this book presents a capsule history of space science — a term used to cover rocket and satellite-borne observations, experiments, and manned missions into near-Earth space and the Moon.

All but one of the chapters are historical summary; the exception is James Van Allen's 1958 paper that described the belts of charged radiation circling the Earth which now bear his name.

Glossary of Astronomy and Astrophysics
Jeanne Hopkins
196 pages, hardcover, $17.50
University of Chicago Press (1980)

This is the second revised edition of a work that was published in 1976. Half the entries have been revised and updated, and 350 new ones have been added to the previous 2000.

Volcanoes
Robert and Barbara Decker
244 pages, hardcover, $17.95; paperback, $8.95
W. H. Freeman (1981)

Volcanic activity has certainly had a major role in shaping the face of the Earth. The Deckers' book looks at terrestrial volcanoes and discusses their effects on landforms and the chemical evolution of the crust and atmosphere. There are many good black and white illustrations.

Fire of Life
262 pages, hardcover, $24.95
Smithsonian Institution Press (1981)

The "fire of life" of the title is the Sun. The book (intended for a general reader) deals with the Sun and its effects at all scales from that of the solar system as a whole down to the future of solar energy in human civilization. It has over 300 color photos.

The Calculator Afloat
Henry H. Shufeldt and Kenneth E. Newcomer
225 pages, hardcover, no price given
Naval Institute Press (1980)

First published in 1972 as *Slide Rule for the Mariner*, this book covers a lot of topics; more, in fact, than many navigators will need. Examples are given and worked through. For the most part, the authors have provided formulae rather than keystroke routines because such an approach is more adaptable to the widely varying "languages" calculators and small computers employ.

Computational Spherical Astronomy
Laurence G. Taff
233 pages, hardcover, $28.95
Wiley-Interscience (1981)

Taff's book is chiefly concerned with reducing positional measurements made on stars, planets, and Earth satellites. The level of treatment is highly mathematical.

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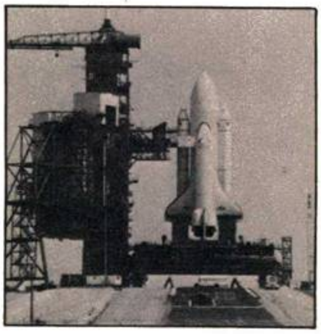

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The astrolabe is a "computer" designed for telling time from the positions of the Sun and stars. It utilizes a theory of stereographic projection developed about 150 B.C. in Alexandria, Egypt, but the instrument itself isn't described in detail in astronomical literature until about 530 A.D. It has continued in the same essential form for about 1200 years.

Most are elaborately ornamented (varying with the culture and times), but the decoration is functional as well as beautiful.

Using one, you can calculate sidereal time, solar time, time from the altitude of the Sun, sunrise and sunset for any day of the year, rising and setting of 21 stars and — with the aid of an almanac — positions of the Moon and planets. The astrologically inclined can use their astrolabes to cast horoscopes.

When you assemble the kit, you'll find patience essential — not because it's complex, but because you'll need solid joints with the gold metallic-plated cardboard materials. Be sure to give the glue plenty of time to dry! The weakest points are the sights of the alidade, and care must be taken not to bend them.

When your astrolabe is finished, you can enhance its appearance by coating the exposed cardboard edges with gold-colored paint. But even as it is, the astrolabe is a very handsome instrument.

Clear assembly directions are given in an accompanying 24-page booklet which also describes the history, illustrates the variety, and explains the geometric logic behind the astrolabe's structure. Soon, you'll find yourself throwing around arcane terms like *tympan*, *rete*, *almucantar*, and *alidade*.

There is a fascination here that grows with your knowledge of the instrument. Mathematics and geometry were never simple for me and I did have to struggle a bit with some of the diagrams and principles involved. However, when I got all the parts assembled and understood the procedures (a clear sky and the ability to distinguish Rigel from Arcturus were also very helpful), it actually worked — give or take a few minutes!

Let's face it, your quartz digital watch is far more accurate. But the astrolabe is more versatile, a whole lot more fun, and looks good hanging on the wall.

For the affluent, MacAlister offers a hand-crafted, solid brass astrolabe of 2⅝" diameter. Price? $975.

MacAlister also has (for $20) a kit to make three working cardboard models of Renaissance time instruments — a sundial, a nocturnal calendar, and a perpetual calendar. I don't think I can resist them. *Bruce Bond.*

The Messier Catalogue

P. H. Niles, ed. and translator
52 pages, paperback, $1.50
Auriga (1981)
[Order from the publisher, Box F, 8 Candlelight Ct., Clifton Park, NY 12065]

Niles has taken the final version of the Messier catalog as published in *Connaissance du Temps* of 1787 and translated the descriptions for each object. He has attempted — at the risk of clumsy English — to retain the syntax and rhythm of the French original. At the back of the book, he lists the objects, giving their constellations, what type of object they are, and positions for 1950, 1980, and 2000.

Infrared Astronomy

C. G. Wynn-Williams and D. P. Cruikshank, eds.
376 pages, paperback, no price avail.
D. Reidel Publishing (1981)

This book records the proceedings of a symposium sponsored by the IAU in June 1980. The papers, all technical, cover a wide range of topics — from planetary atmospheres to interstellar dust and the center of our Galaxy.

Master List of Nonstellar Optical Astronomical Objects

Robert S. Dixon and George Sonneborn
835 pages, hardcover, $30
Ohio State University Press (1980)

This massive tome lists, by 1950.0 right ascension, all nonstellar optical objects contained in all catalogs published through 1975. It gathers some 270+ catalogs with a total of about 185,000 entries into one list and gives the original catalog designation and information on position, size, magnitude, and type.

You can scan along until you find an interesting item, then look at the entries in the column just above and below for something with the same position. You may discover that your object is listed in another catalog (of supernova remnants, say), but under a different designation — which is what makes this book so useful.

Because astronomers have gone nomenclature-happy in the past few decades, a cross-referenced list such as this one is crucial in sorting out bits of information scattered throughout published literature.

Astrophoto IV

John Sanford, ed.
80 pages, paperback, no price given
Orange County Astronomers (1981)
[Order from OCA, 2215 Martha Ave, Orange, CA 92667]

This book — a reprint of the papers given at the fourth conference on astrophotography sponsored by the OCA and the Ventura County Astronomical Society — contains 15 articles that will interest astrophotographers. Topics include: hypersensitizing, image intensification, solar eclipse photography, and deep-sky photography with ordinary telescopes.

Update on Space, Vol. I

B. J. Bluth and S.R. McNeal, eds.
196 pages, paperback, $7.95
National Behavior Systems (1981)

The 8 articles in this anthology look at topics in future space development such as space stations, space industrialization, materials processing, and the role of the military. Many of the authors work for, or are otherwise connected with, the development departments of "space-faring" companies.

It's All Relative

Necia H. Apfel
143 pages, hardcover, $9.95
Lothrop, Lee, and Shepard (1981)

Although written for young adults, this summary of Einstein's theory of relativity would make an easy introduction to the subject for anyone who wants to learn the basics.

Other Worlds

Paul Davies
208 pages, hardcover, $11.95
Simon and Schuster (1980)

Principally, *Other Worlds* is a description of how quantum mechanics — which revolutionized physics in the 1930s — has changed the view scientists have of the world. Davies assumes his reader knows little of the subject and nothing of mathematics.

Large Aperture Optics

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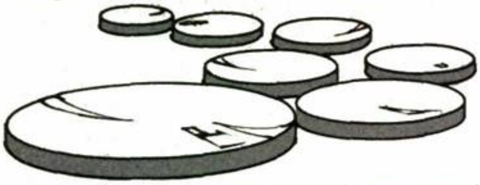

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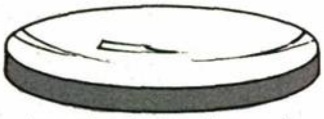

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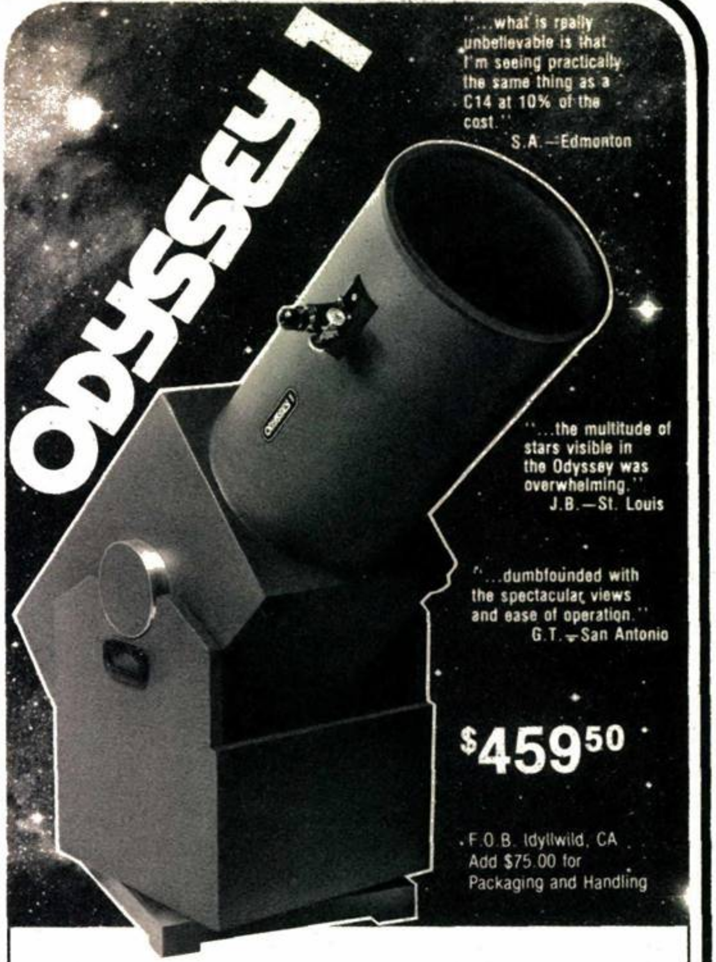
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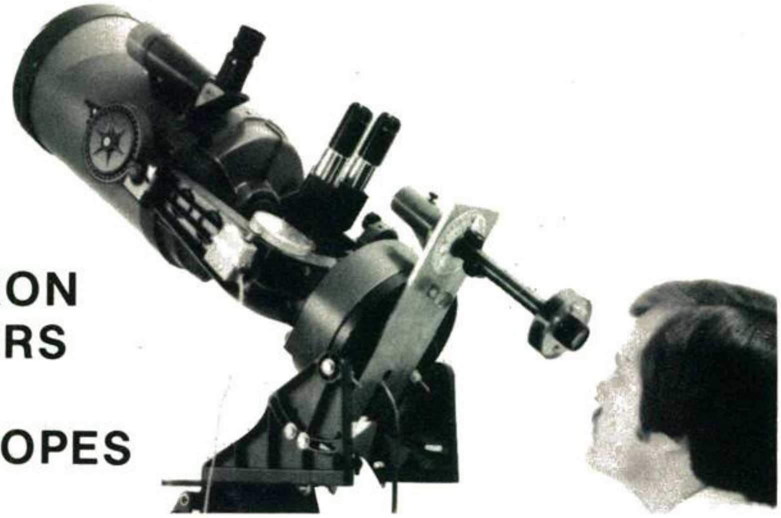

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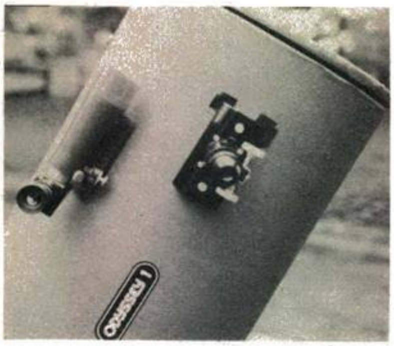

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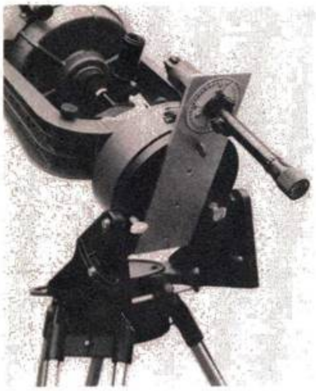

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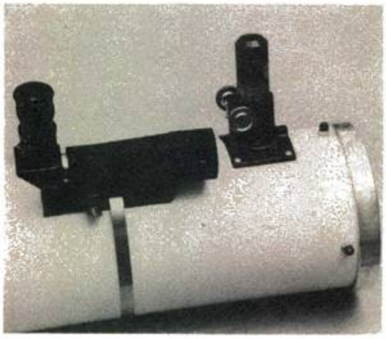

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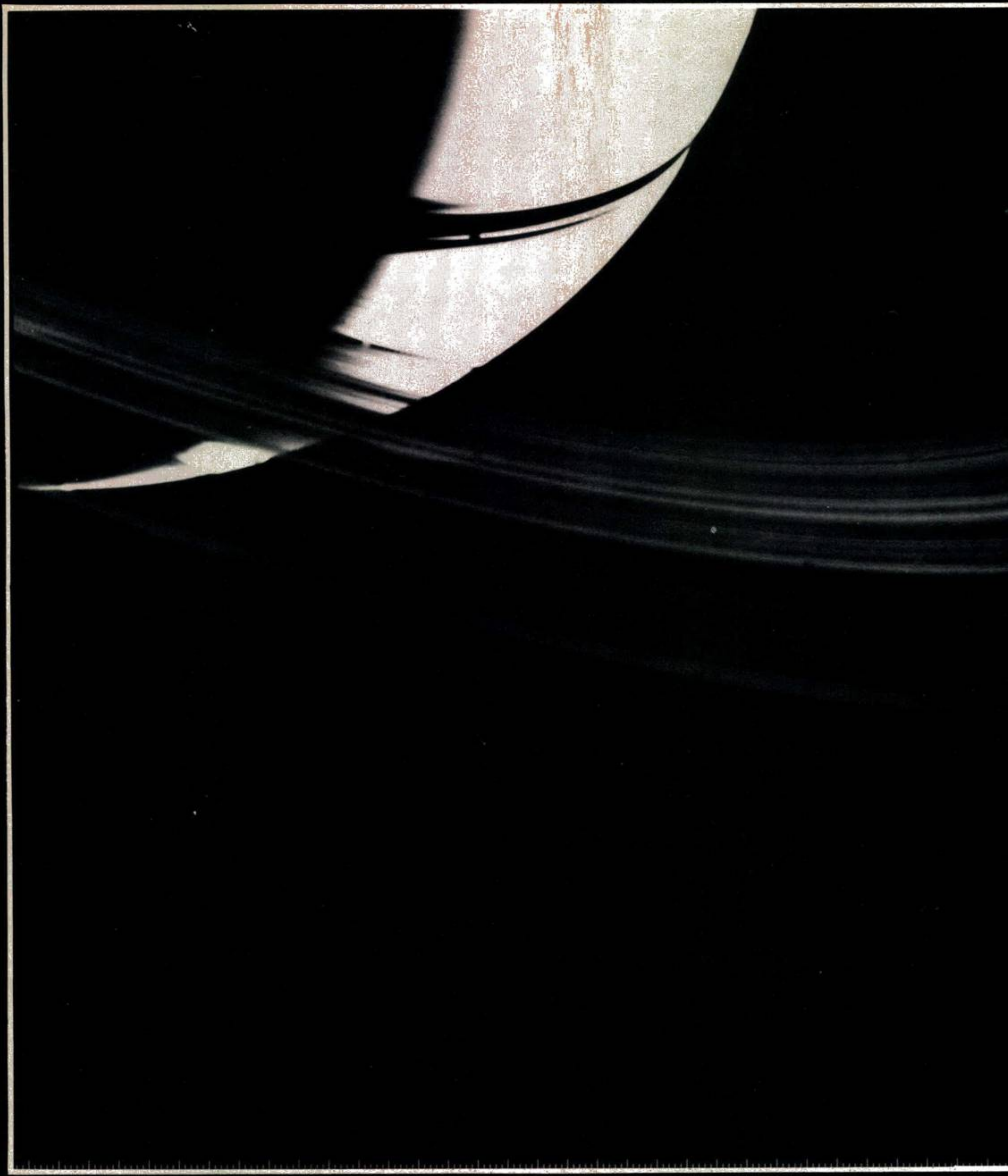

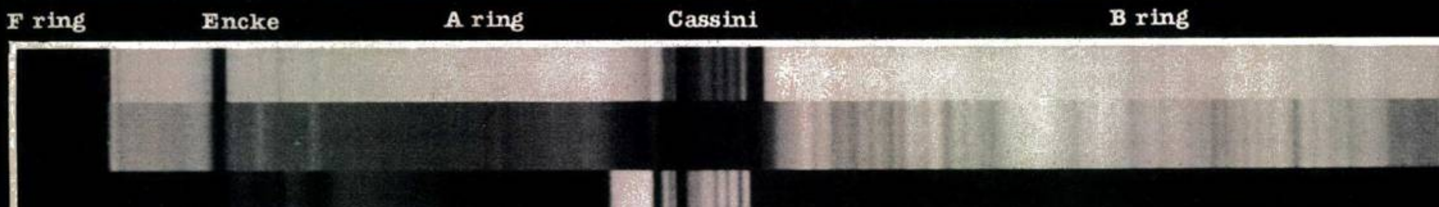
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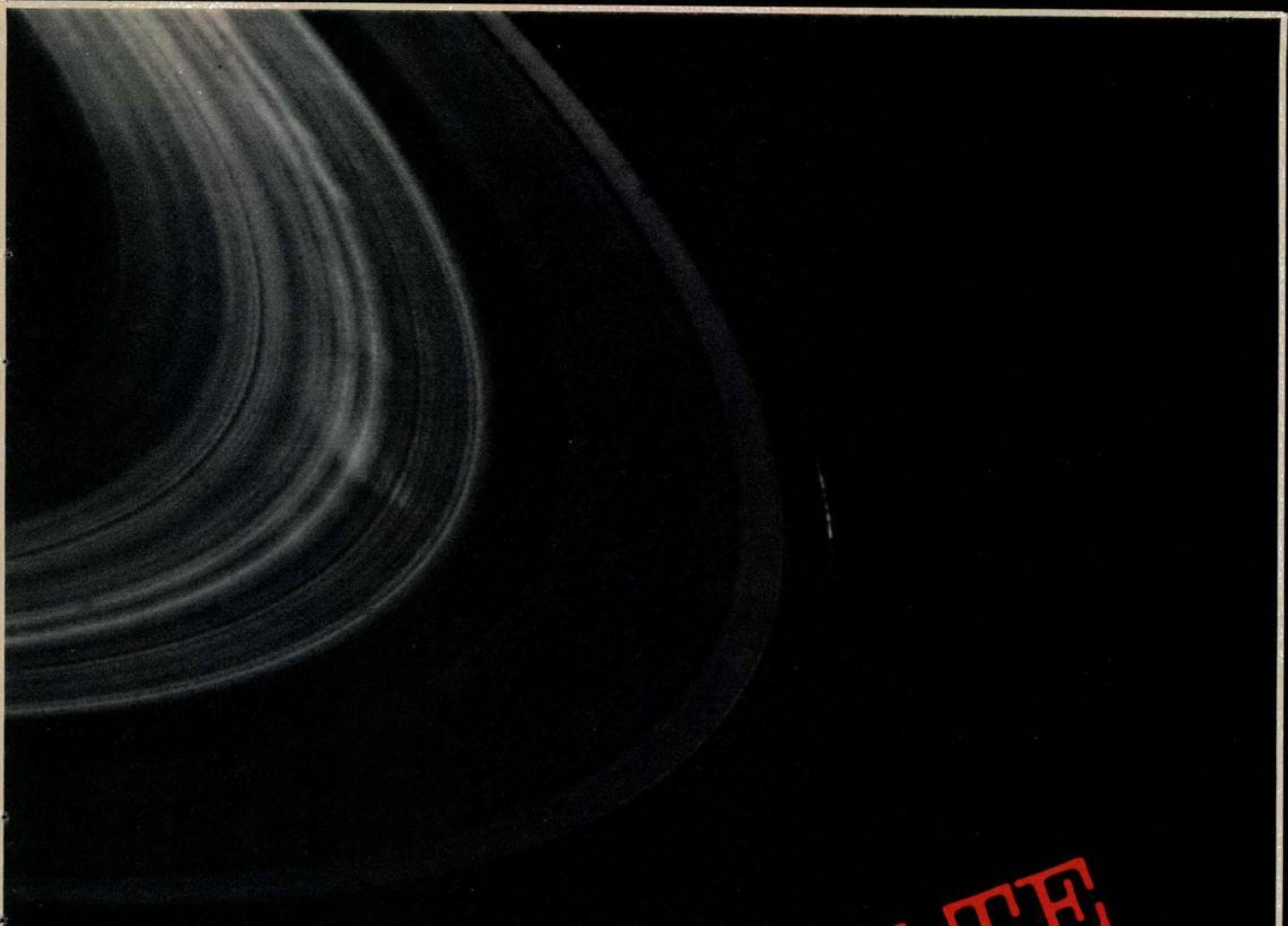
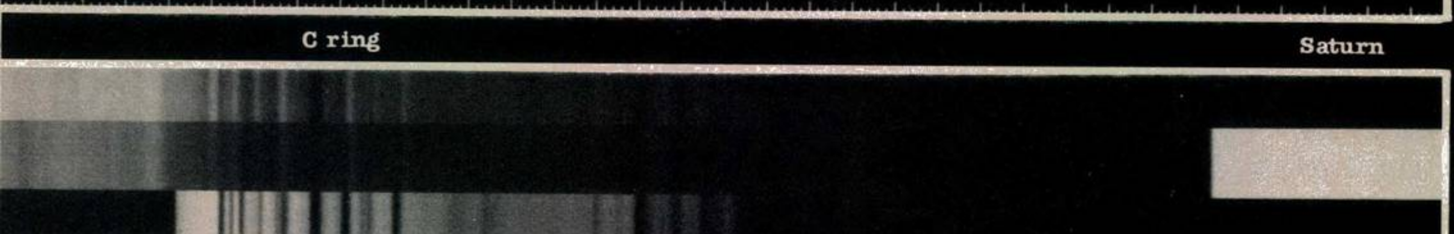
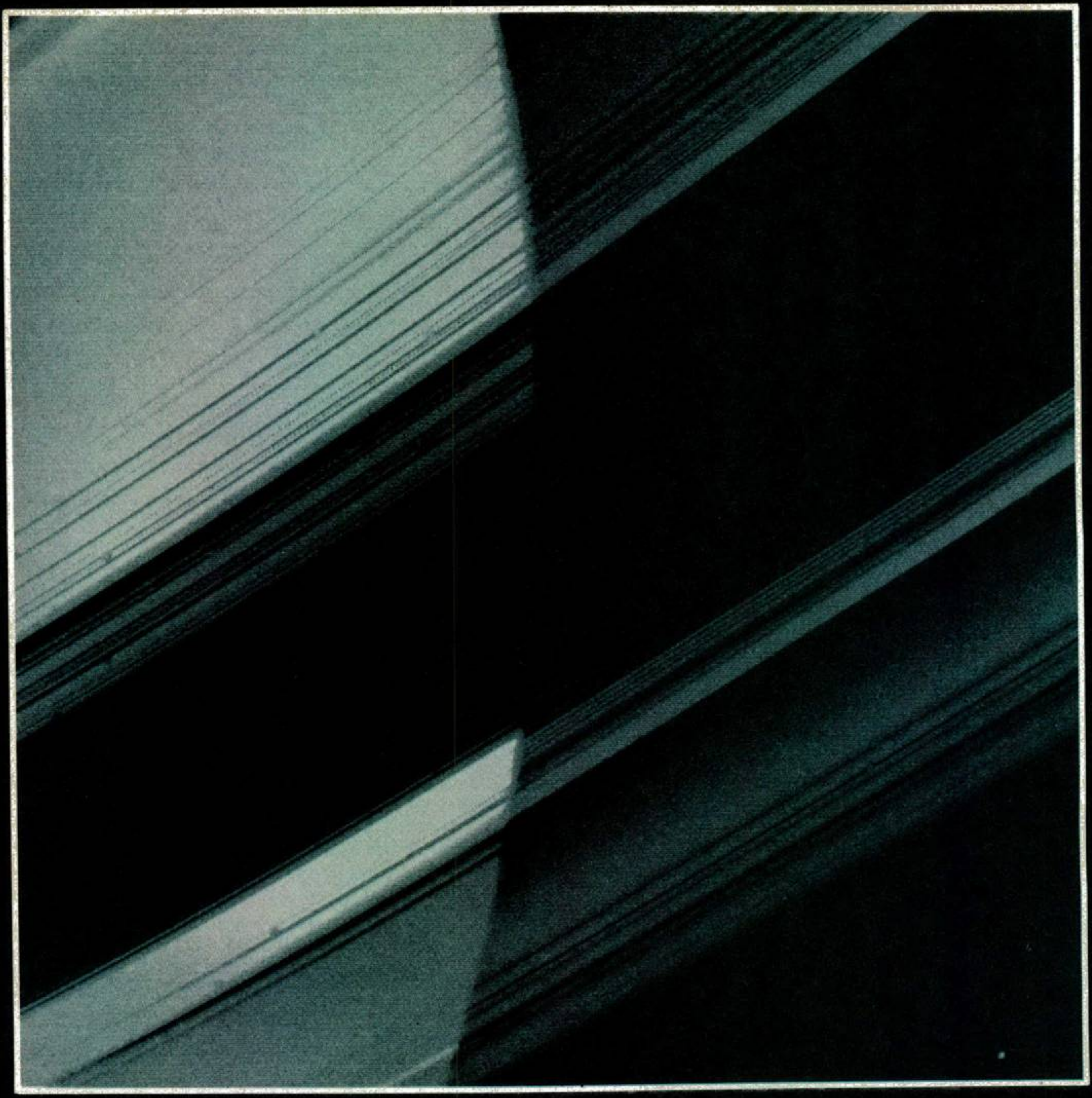


SATURN UPDATE

Looking back at Saturn and its rings as it left the system, Voyager returned this crisp perspective never visible from Earth. Below: Each band represents the rings of Saturn in a specific type of lighting. The top band shows the rings as we normally see them from Earth; the middle band as an observer "looking back" from beyond Saturn; the bottom band the unilluminated side of the rings. All three bands are shown to the same scale, with Saturn at the right.





Here the unilluminated side of Saturn's ring system passes in front of the disk of the planet. Opaque parts of the ring block light from the planet behind them; translucent places allow a peek at the planet. The rings glow against the dark of space because light is scattered through them.

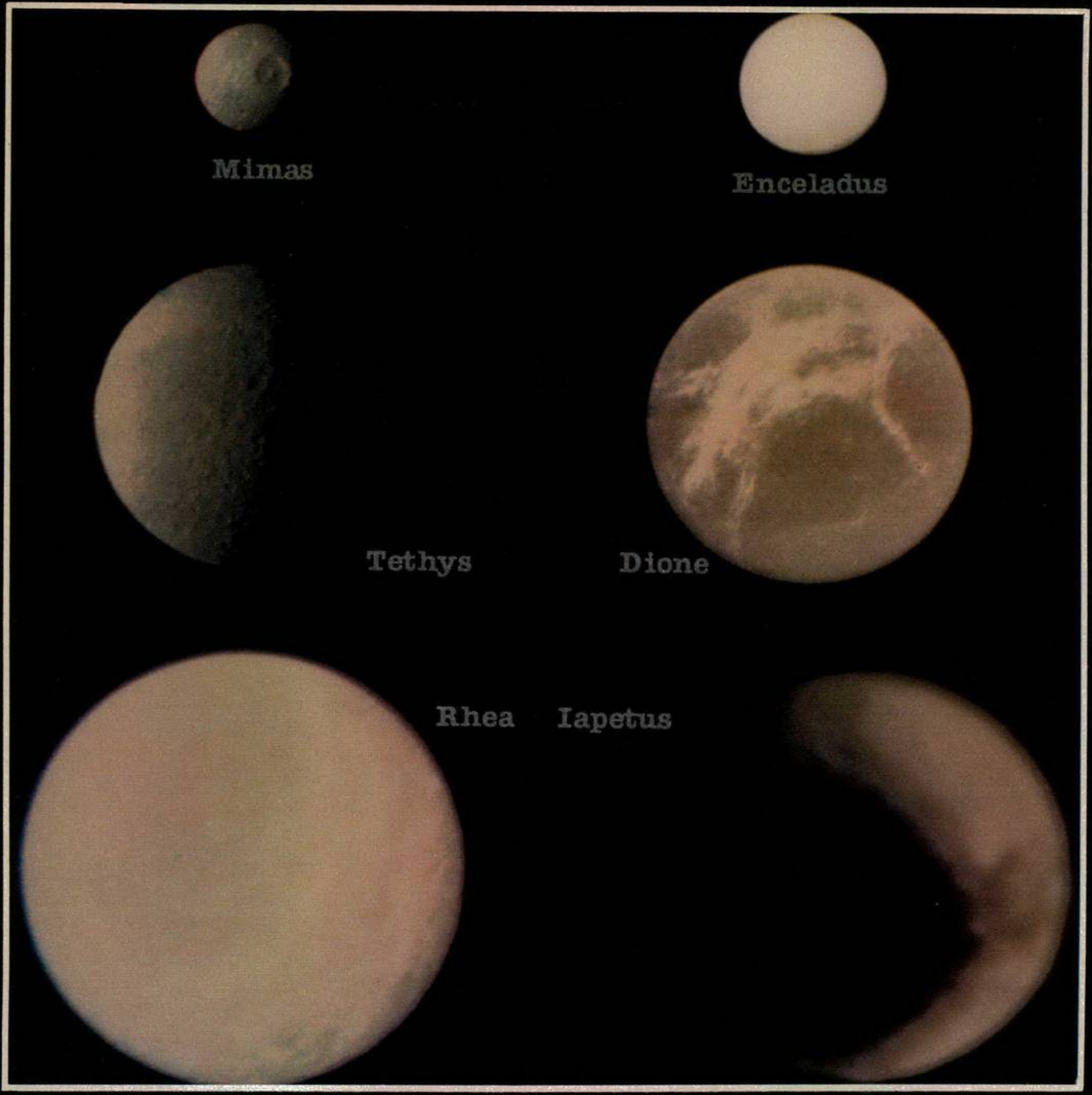
Even as Voyager 2 homes in on Saturn for closest approach on August 25, scientists are studying and analyzing the wealth of data and images returned by Voyager 1 last November. Although many major questions remain, on more refined analysis, several of the most perplexing preliminary results described in the January and February, 1981 issues of ASTRONOMY have been resolved.

One of the most confusing aspects of the data was the seeming contradiction between theories of planetary interiors and the measurements made by Voyager 1 of the helium/hydrogen ratio. According to the theories, helium should have condensed and "sunk" to the core of Saturn about 2.5 billion years ago, as the planet cooled. In Jupiter, larger, hotter, and slower to cool, the rain of helium should have not yet occurred — although as Jupiter cools, eventually it will.

Before the flyby, scientists therefore expected that the ratio of helium to hydrogen in Saturn's atmosphere would be lower than the ratio in Jupiter's atmosphere. However, the first results — announced within days of the flyby — suggested that the ratio appeared to be the same at both planets — causing some consternation for the theorists.

The measurement, a rather complex one involving several experiments, has now been more fully analyzed. The results show that Saturn's atmosphere contains about 11% helium by weight, whereas Jupiter's contains about 19%. This appears to confirm that gravitational separation has indeed occurred. Gravitational separation is needed to account for the excess thermal radiation that Pioneer 11 observed from Saturn.

Another perplexity was the radial spokes seen in the rings. Initially, measurements of a small number of spokes



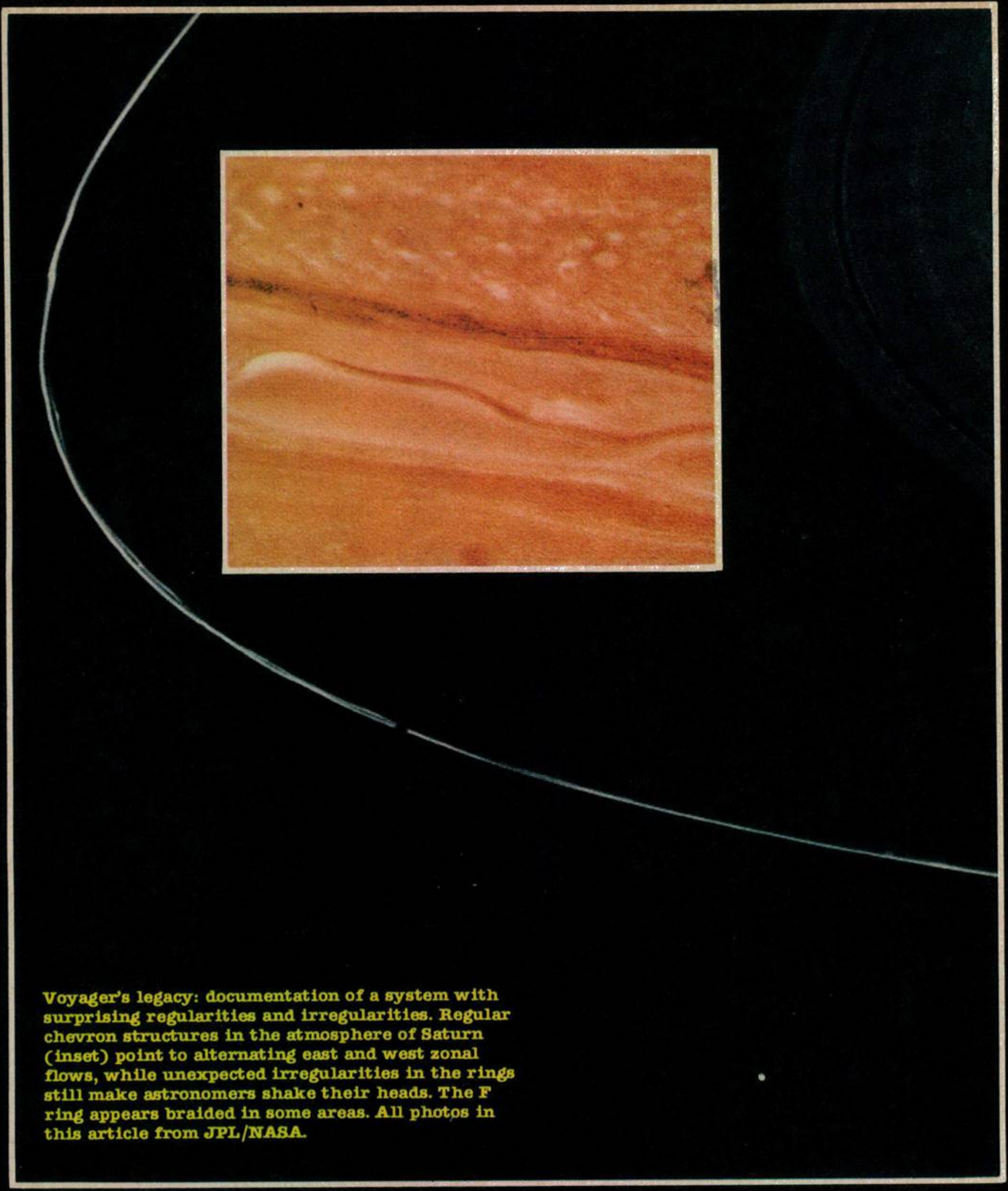
Six of Saturn's icy satellites are shown at the same scale, brightness, and color in this composite picture made at JPL. Note the brilliance of Enceladus, the split brightness of Iapetus, and the large-scale wispiness of Dione and Rhea.

seemed to show that the spokes rotated rigidly with Saturn — as if they were embedded in, or attached to, the planet's magnetic field. A larger set of measurements now shows that this is not the case: the spokes rotate in a "Keplerian" fashion. Along most of their length, the spokes rotate independently of Saturn's magnetic field. Although the magnetic field probably has something to do with their formation, it does not control the spokes after their creation.

More results have poured in on the rings. The apparent similarity between the particles in the C ring and the Cassini Division, which are unlike the A and B rings, still holds up. But no clear-cut pattern of features tidies the rings into a simply understood system. The B ring, for example, contains an abundance of very fine dust — but also probably contains many kilometer-sized moonlets that clear the 10 kilometer wide mini-divisions that characterize the B ring. Radio science postulates the "typical" A ring particle size at 10 meters, the outer edge of the Cassini Division as having 8-meter chunks, and the C ring as having a 2-meter chunk size — all considerably bigger than most astronomers believed Saturn's ring particles to be before the flyby.

From the ultraviolet instrument comes another interesting finding about the rings: they are enveloped in a tenuous hydrogen atmosphere. It contains roughly 600 million hydrogen atoms per cubic meter, and the whole hydrogen cloud masses roughly 1,000 tons. The hydrogen presumably comes from water ice in the rings.

In addition, several new rings were found. Inside the C ring is another still fainter ring, the D ring, recorded on several long-exposure photographs. Outside the A and F rings, lie two more faint rings, the G ring and the E ring. The G ring is narrow, and lies about 168,000 km from the center



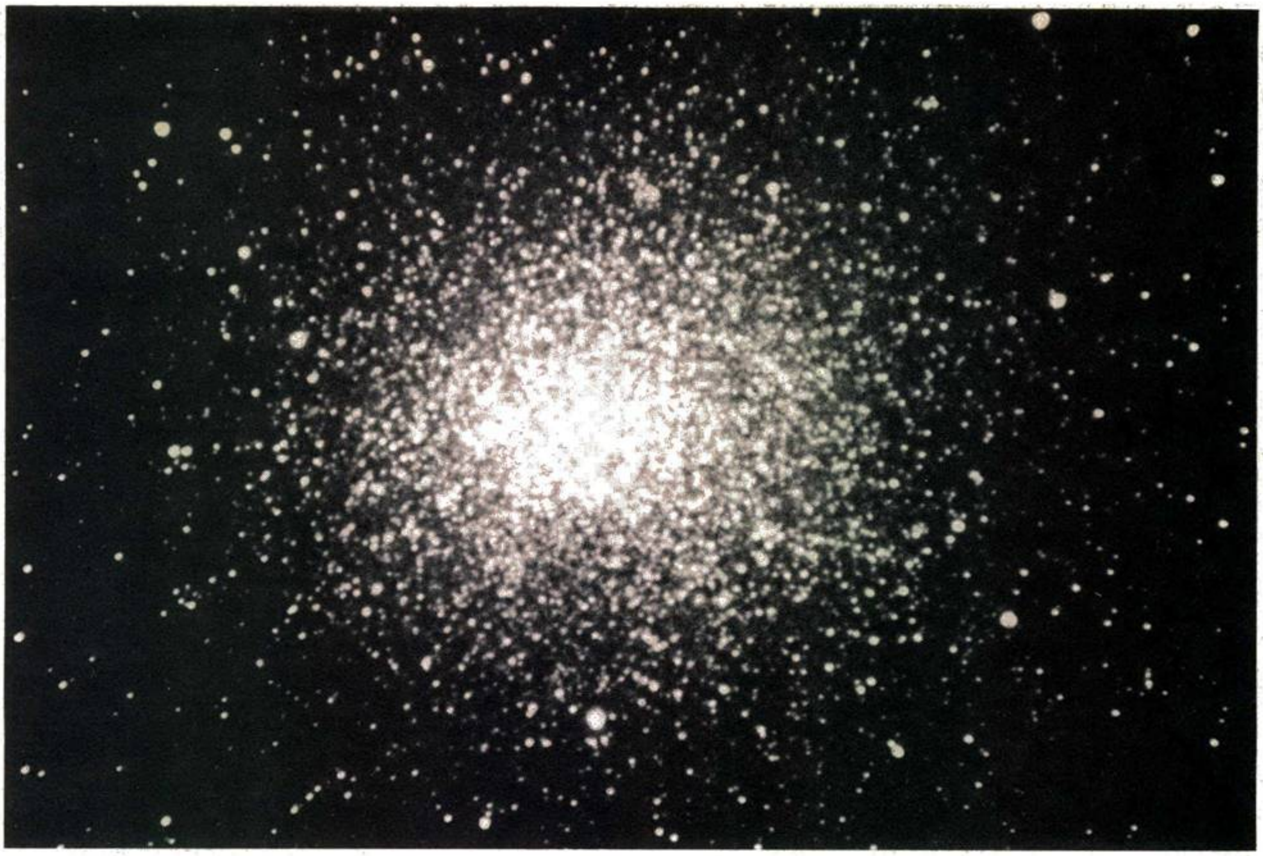
Voyager's legacy: documentation of a system with surprising regularities and irregularities. Regular chevron structures in the atmosphere of Saturn (inset) point to alternating east and west zonal flows, while unexpected irregularities in the rings still make astronomers shake their heads. The F ring appears braided in some areas. All photos in this article from JPL/NASA.

of Saturn. The E ring, very much fainter and broader, extends from about 210,000 to 300,000 km from Saturn. From its optical properties, it seems to be made of extremely fine material.

Meanwhile, the F ring continues to be a puzzle. Lying outside the A ring and flanked by two tiny satellites, it consists of three close 20 kilometer wide ringlets. Two of the ringlets intertwine in some places, an effect that astounded the Voyager imaging team. Measurements on successive pictures show that the clumpiness and braid features in the F ring rotate around Saturn in about 15 hours — the same speed as the discrete particles making them up. Crossover points in the braiding occur about every 700 kilometers, and the displacement of the ringlets is about 30 kilometers.

Although astronomers are fairly certain that gravitational interactions with the two "sheepdog" satellites can explain the "braiding," Voyager 2 has been reprogrammed to obtain a much larger number of images of the F ring than originally planned. This should provide a three-dimensional view over a larger period of time than Voyager 1 did.

— Richard Berry



THE QUESTAR® 7 PHOTOGRAPHS OMEGA CENTAURI

This remarkable photograph of Omega Centauri was taken at Apache Pass, Arizona, by Hubert Entrop. He writes us "The wind blew from the west in strong gusts but I located in a low north-south arroyo beside a large bush to protect the scope. The atmosphere was miserably rough but in spite of it, it's a good Omega Centauri. Imagine what it would be like if we could have it straight overhead instead of so low on the horizon. Exposure 1 hour 30 minutes on Tri-X."

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If you come past Questar these days you will see the newest feature on our landscape—the Observa-Dome, which we are now privileged to offer to our customers in a variety of sizes. It is equipped with the new Questar Telescope Mount which accommodates our Questar 12 and is engineered to support a telescope as large as 20 inches. The design of the mount is an adaptation of the German equatorial, with special Questar features that contribute to the mechanical perfection for which Questar products are noted. Unlike some recently introduced mounts, it has a full 360° continuous following capability, with a smoothness of operation that must be experienced to be believed.

Also at Questar, if you have an interest in surveillance or special tracking applications, you will see our patented 40-120 on display. This unique instrument establishes prime focus at both 40 and 120 inches (1000 and 3000 mm.) It resolves 100 lines per millimeter at the lower focal length and at least 55 lines per millimeter at the upper; one can move in a few seconds between the two and since the shift is managed by internal optical change the barrel length remains at a constant 30 inches. It weighs only 40 pounds.

In many ways the Questar 40-120 is the most sophisticated of the Questar instruments. Its size and weight make it ideal for a variety of uses where the observer must be at a great distance from the area or activity under scrutiny, while the dual focal length is particularly important for objects in motion.

Literature on the Questar 40-120 and on the Observa-Dome is available on request.

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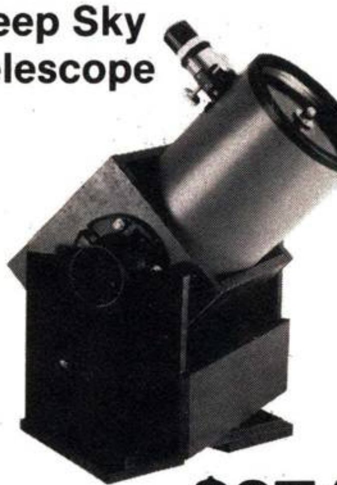

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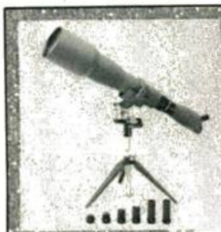

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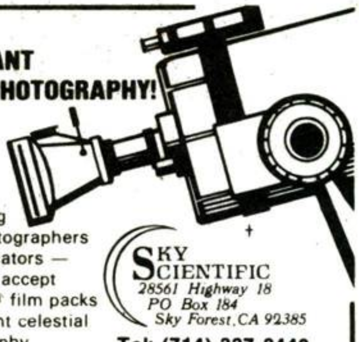

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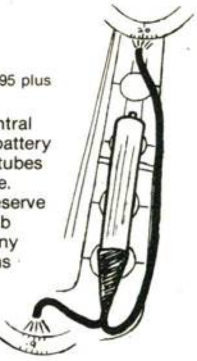

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ANNOUNCEMENT — Telescope users clinic presented by Western Observatorium October 3, 1981 at Rio Hondo College, 3600 Workman Mill Rd., Whittier. 1:00 p.m. Donation $2 per person, $3 per family. For information, contact Western Observatorium, 13215 E. Penn St., Suite 411, Whittier, CA 90602. Phone (213) 698-0468.

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close-up on vulpecula region

through the eyepiece

The best astronomical event of August is the annual Perseid meteor shower — and this year's display should be very good. Other events include a striking naked-eye array of four planets with the Moon in the evening sky and the emergence of Mars in the morning sky.

Mercury

Passing superior conjunction on the 10th, Mercury will remain out of sight for most of August. Only late in the month will you get a chance to glimpse the planet, very low in the western sky after sunset. On August 31, Mercury sets about 40 to 45 minutes after the Sun — depending on your latitude.

Venus

Venus' two conjunctions, with Saturn on the 25th (at 22:17 UT) and with Jupiter on the 28th (at 0:37 UT), will be interesting to view and photograph. Venus passes almost 2° south of Saturn and less than 1° south of Jupiter.

But this is only the finale to a stately procession that has gone on all month. Each evening, Venus will climb a little farther away from the twilight glow of the Sun. The Moon, passing swiftly through the area, will overtake Venus on the 2nd. Then, Venus will steadily close in on the Jupiter-Saturn pair.

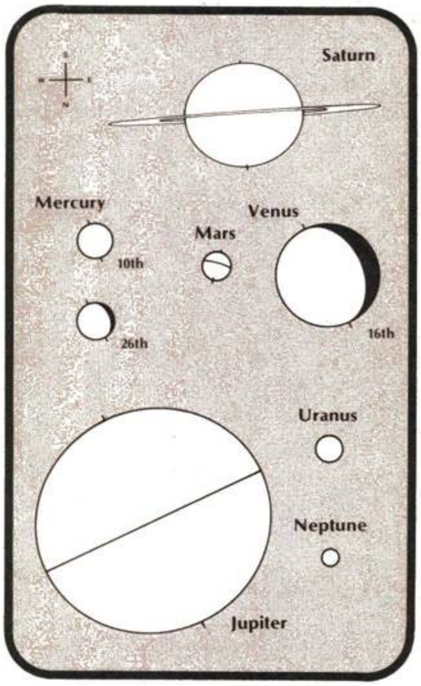
By the last week of August, the three will form a small triangle about 2° across. To capture all three — and a little foreground for added effect — use a lens in the 85mm to 100mm range (assuming 35mm format). Longer telephotos will crop in tighter on the planets, but lose the foreground.

Right after sunset on the 31st, there'll be a fine grouping of Mercury (if you're sharp-eyed), the Moon, Saturn, Jupiter, Venus, and Spica — all strung out along the ecliptic in the west-southwest. Since the objects spread over an angle of about 27°, any 35 mm camera with a normal lens will encompass the sight.

Although greatly diminished from their brilliance at Full Moon, the rays of Tycho are still visible as they traverse crater and mare, approximately a day before Last Quarter. In winning the "Best Astro-Photo" award for August, John Asztalos used 64 ASA film, a 12-inch reflector at f/20, and a 1/8 second exposure.

Mars

Mars has now emerged from the Sun's glare and is becoming relatively prominent in the predawn sky. But Mars' small apparent disk (4.1" of arc) — the result of viewing a 6790-kilometer-diameter planet from 344,000,000 kilometers' distance — makes it something of a disappointment in the eyepiece.



The telescopic view will improve over the months to come until Mars reaches opposition on March 31, 1982. (In fact, the view at each opposition between now and late September 1988 will steadily improve.) But even at opposition next year, Mars' apparent diameter will be only 14.7" of arc. You'll have to wait for those nights with good seeing and then crank up all the power the atmosphere will allow.

On the morning of August 26, a crescent Moon (3 days before New) will lie a degree or two to the right of Mars. Look for the stars Castor and Pollux to Mars' upper left and Procyon below the Moon and to the right. Orion and Sirius will also be visible in the southeast.

Asteroids

1 Ceres (magnitude 8.2) is in Leo and fast disappearing into the twilight glow of sunset. On the 1st, Ceres sets about an hour and a half after the Sun; by the 31st, it sets only 55 minutes after. (Conjunction with the Sun comes on September 15.) Its positions:

10th: 10h 42m 24s, +16° 29.4′
20th: 10h 59m 35s, +14° 44.6′

2 Pallas (8.8), in western Hydra, is emerging from the Sun's glare in the predawn sky. Too close to the Sun to be seen at the beginning of August, by month's end Pallas is rising some 45 minutes ahead of sunrise. Positions:

10th: 8h 29m 49s, -0° 03.8′
20th: 8h 51m 21s, -0° 40.4′

3 Juno (11.5) lies in eastern Virgo. Positions:

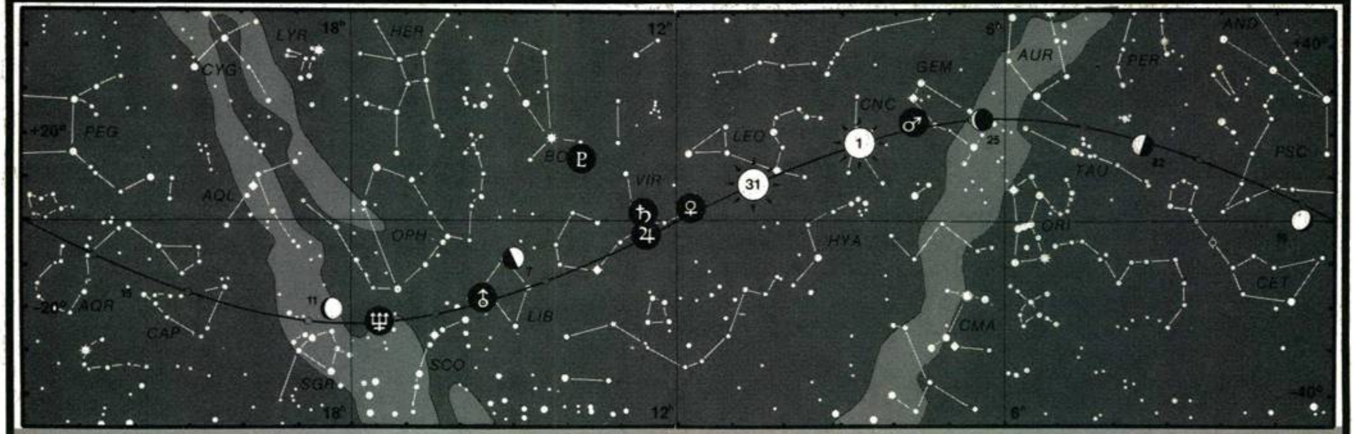
10th: 14h 01m 57s, -1° 28.9′
20th: 14h 10m 18s, -2° 28.5′

On the 25th at 19:08 UT, Juno will pass 3′ of arc north of the 6.0 magnitude star, SAO 139830. (This star lies 2° 48′ almost due north from 4.1 magnitude Iota [ι] Virginis.) You won't see the moment of conjunction because it comes during daylight for North America, but later that evening you'll see the asteroid just to the southeast of the star and very close.

4 Vesta (8.0) is moving eastward in Leo. Positions:

10th: 12h 18m 49s, +4° 03.3′
20th: 12h 35m 58s, +1° 59.0′

planetary data august 1981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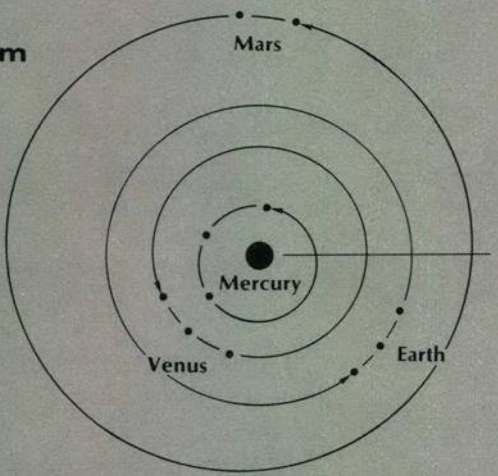
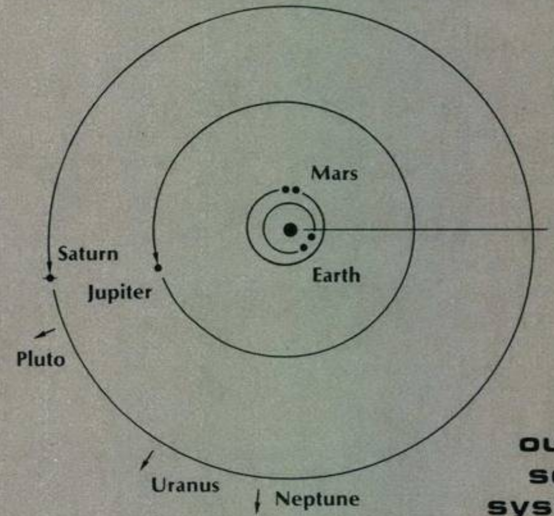
inner solar system


Mars
Mercury
Venus
Earth


Mars
Saturn
Jupiter
Earth
Pluto
Uranus
Neptune

outer solar system

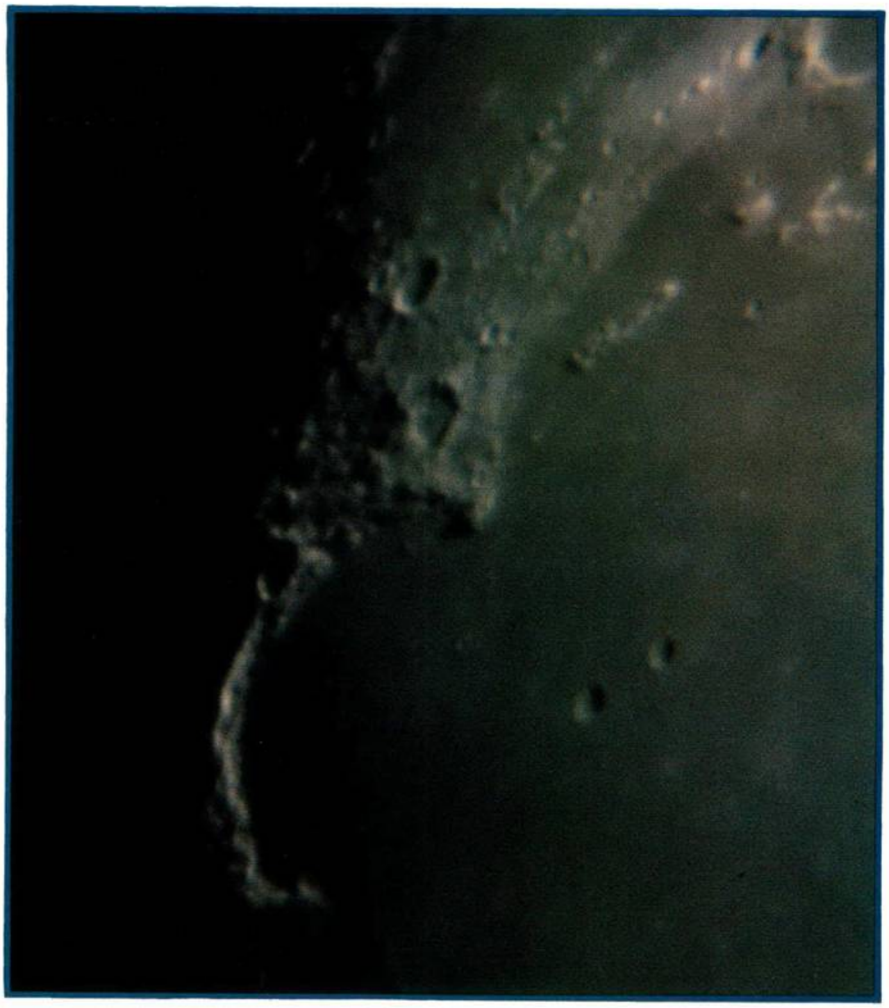
				Angular	%	Distance (AU) from:		Longitude:			
		Date	Mag.	Size	Illum.	Earth	Sun	Heliocentric	Ecliptic	R.A. (1981.7)	Dec
Sun		1	-26.7	31.6′	—	1.01	—	—	128°39.9′	8h 44.3m	+18°05.9′
		15	-26.7	31.6′	—	1.01	—	—	142°05.2′	9h 37.8m	+14°09.1′
		31	-26.7	31.7′	—	1.01	—	—	157°30.5′	10h 36.8m	+ 8°45.4′
Mercury	☿	1	- 1.3	5.4″	90%	1.25	0.31	82°34.7′	118°05.3′	8h 03.1m	+21°26.0′
		15	- 1.3	4.9″	100%	1.36	0.36	161°06.9′	146°33.6′	9h 59.4m	+14°07.0′
		31	- 0.3	5.2″	86%	1.28	0.44	219°51.2′	174°54.1′	11h 43.6m	+ 2°09.2′
Venus	♀	10	-3.4	12.7″	83%	1.33	0.72	218°38.2′	169°18.9′	11h 24.1m	+ 5°06.1′
		31	-3.4	14.1″	77%	1.19	0.73	252°08.1′	194°19.3′	12h 54.6m	- 5°40.3′
Mars	♂	15	+1.8	4.1″	97%	2.30	1.56	87°17.4′	107°55.1′	7h 20.0m	+22°56.9′
Jupiter	♃	15	-1.3	32.3″	100%	6.10	5.45	196°12.7′	188°02.8′	12h 33.0m	-2°17.6′
Saturn	♄	15	+1.2	16.2″	100%	10.29	9.60	191°07.2′	186°25.0′	12h 28.7m	-0°38.2′
Uranus	⛢	15	+5.9	3.7″	100%	18.73	18.83	239°10.8′	239°57.3′	15h 35.3m	-19°05.2′
Neptune	♆	15	+7.7	2.5″	100%	29.75	30.27	263°51.0′	263°17.4′	17h 26.3m	-21°52.7′
Pluto	♇	15	+14.0	—	100%	30.50	30.03	203°50.2′	205°10.0′	13h 46.7m	+7°02.0′

moon data

First Quarter .... August 7 at 19:26
Full Moon .... August 15 at 16:37
Last Quarter .... August 22 at 14:16
New Moon .... August 29 at 14:43
First Quarter .... September 6 at 13:26
Full Moon .... September 14 at 03:09
Apogee: August 8 at 12h ...... 404,227 km
Perigee: August 21 at 21h ..... 369,652 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in Through the Eyepiece are UT unless noted otherwise. To convert UT into your local daylight time, subtract the following number of hours for each time zone: EDT, 4; CDT, 5; MDT, 6; PDT, 7; Alaska, 9. For example, if an event is to happen at 03:00 hours UT on June 7, then EDT for the event is 11 p.m., June 6. Likewise, 03:00 UT on September 2 becomes, in PDT, 8 p.m., September 1.



The low-angle illumination of sunrise brings out subtle relief on the floor of Sinus Iridum. At top is the short line of the Montes Recti; below are the twin craters Helicon (left) and Leverrier. James Bailey used an 8-inch f/10 Schmidt-Cassegrain telescope, a 3x Barlow, 200 ASA film, and a 3-second exposure.

Vesta passes to the north of Saturn on the 16th (3.5° separation at 0:39 UT) and Jupiter on the 20th (4.6°, 7:04 UT). In turn, Vesta is overtaken by Venus on the 31st (at 7:17 UT) when the planet passes 5.5° south of it.

Jupiter and Saturn

Although these two planets will be visible low in the evening twilight for several weeks, this is the last month in the current apparition for adequate telescope viewing.

Uranus

Uranus is at the western end of its retrograde loop, and will spend most of August nearly stationary — about 40′ of arc to the west of 5.5 magnitude 41 Librae. Westward motion ceases on August 4; between then and the 31st, the planet will progress about 20′ of arc eastward along the ecliptic. Look for a small greenish disk 3.7″ of arc in diameter.

Neptune

Also near the western end of a retrograde loop is Neptune. The planet's motion during August is 18′ of arc almost due west; its stationary point comes on September 3. It lies some 3.4° northeast of Theta (θ) Ophiuchi, a magnitude 3.3 star. Neptune's 7.7 magnitude disk is 2.5″ of arc across.

Meteors

August is Perseid month and this year's display promises to be a good one. Last year's number was high — so let's keep our fingers crossed.

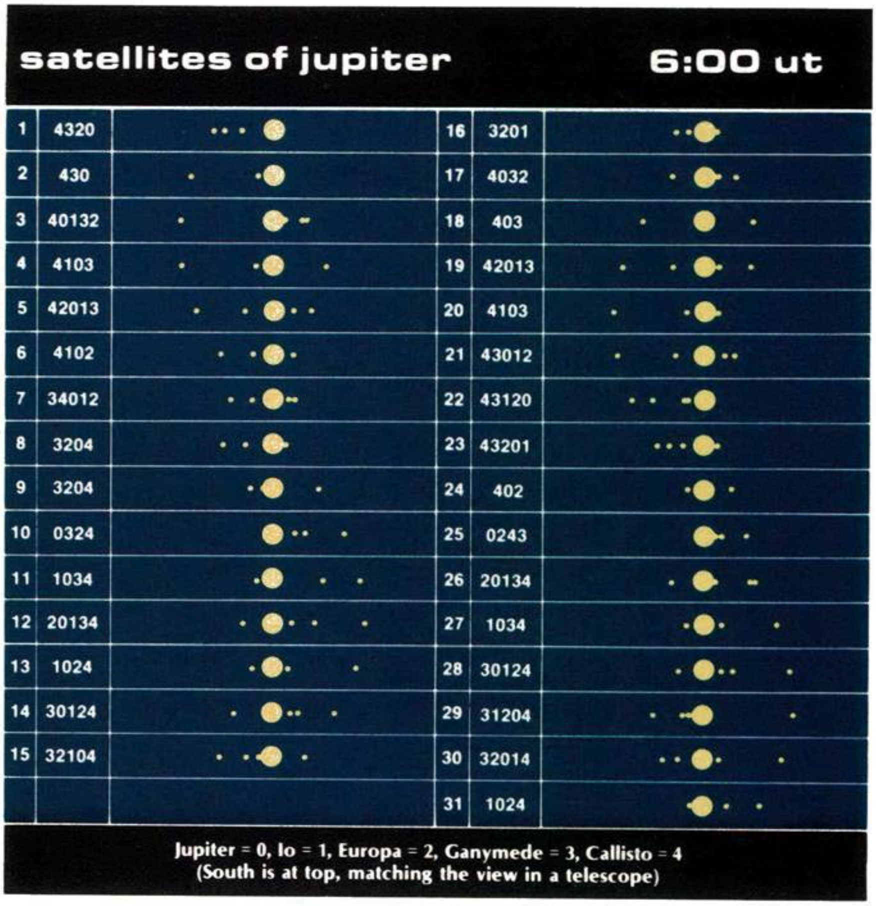
The peak of activity will be around 5:00 to 10:00 UT on August 12. This translates to 1:00 to 6:00 a.m. EDT on the 12th. The Moon will be nearly 3 days short of Full, but its almost round disk will still throw a lot of light until it sets around 2:50 a.m. local daylight time.

The *radiant* (apparent source point on the sky) for the Perseid shower lies between Perseus and Cassiopeia and moves about a degree and a half each day toward the northeast.

The number of meteors we'll see this year is uncertain. The shower often produces some 50 to 60 per hour, but last year's display ran over 100 per hour. The shower's "parent," Comet Swift-Tuttle, has a short orbital period — for comets, that is — of about 120 years. Last at perihelion in 1862, it is due back next year. The increase of Perseid activity in recent years is likely due to the comet's impending return.

The best way to observe a meteor shower is to bundle up — even August nights can be pretty chilly — and lie

satellites of jupiter 6:00 ut



1	4320	16	3201
2	430	17	4032
3	40132	18	403
4	4103	19	42013
5	42013	20	4103
6	4102	21	43012
7	34012	22	43120
8	3204	23	43201
9	3204	24	402
10	0324	25	0243
11	1034	26	20134
12	20134	27	1034
13	1024	28	30124
14	30124	29	31204
15	32104	30	32014
		31	1024

Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4
(South is at top, matching the view in a telescope)

Unlike many globular clusters, M-22 in Sagittarius is visible to the naked eye. It was also the first globular to be discovered. Bill Iburg took this photo with a 14-inch Schmidt-Cassegrain telescope working at f/5.5 with 400 ASA slide film in a cold camera, and using a 25-minute exposure.

out in a lawn chair facing the northeastern sky. Forget telescopes or even binoculars — unassisted eyesight works best. Relax, but don't go to sleep! (Getting together with some friends makes it easier to stay awake — and increases the number of meteors your group will see.)

You'll probably begin to spot the occasional Perseid as soon after sunset as the sky gets dark (the radiant never sets as seen from mid-northern latitudes), but for best viewing, wait until after 1 a.m. local daylight time. By then, the rotation of the Earth has carried you on to the leading hemisphere of the planet. For exactly the same reason that it's the front end of your car that collects the bugs, observers after midnight see more meteors. Good Luck!

close-up on vulpecula region

Four little constellations, three ancient and one "new," nestle snugly in the Summer Triangle. Though Delphinus the dolphin, Equuleus the colt, and Sagitta the arrow date back to antiquity, Vulpecula the little fox was created by Johannes Hevelius in 1690. Originally named Vulpecula et Anser (or variously, Vulpecula cum Ansere), the goose (Anser) has since disappeared — eaten perhaps!

These four small constellations inhabit a region of the Milky Way nearly unsurpassed in views. No matter what instrument you use in this part of the sky — or even if you observe with the naked-eye — there's plenty to see.

Let's start this month's tour with Vulpecula. Bordering Cygnus on the south, Vulpecula measures about 2½ hours of right ascension east and west but only 10° of declination north-south.

Its brightest star, Alpha (α), is of magnitude 4.5 and lies 3° almost due south of the beautiful blue-gold double star, Albireo. If you continue on a line from Albireo through Alpha and extend it a little more than the same distance, you arrive at a curiously-shaped asterism. (It also lies a little over halfway from Vega to Altair.) Known alternatively as Collinder 399 or Brocchi's Cluster, **the Coathanger** is made up of an east-west running line of six stars (all 6th magnitude) and a trio of 5th magnitude ones below. On a clear night, the group is visible to the naked eye as a hazy patch; binoculars or an RFT will break up the haze into its constituent stars and reveal how appropriate a name the Coathanger is.

The famous planetary nebula, **M-27**, the Dumbbell Nebula makes an equilateral triangle with Albireo and the Coathanger. Discovered by the French comet-hunter Charles Messier in July 1764, the 7.6 magnitude nebula has the second-largest apparent size of any planetary. Measuring some 4′ of arc by 8′, it appears distinctly wasp-waisted.

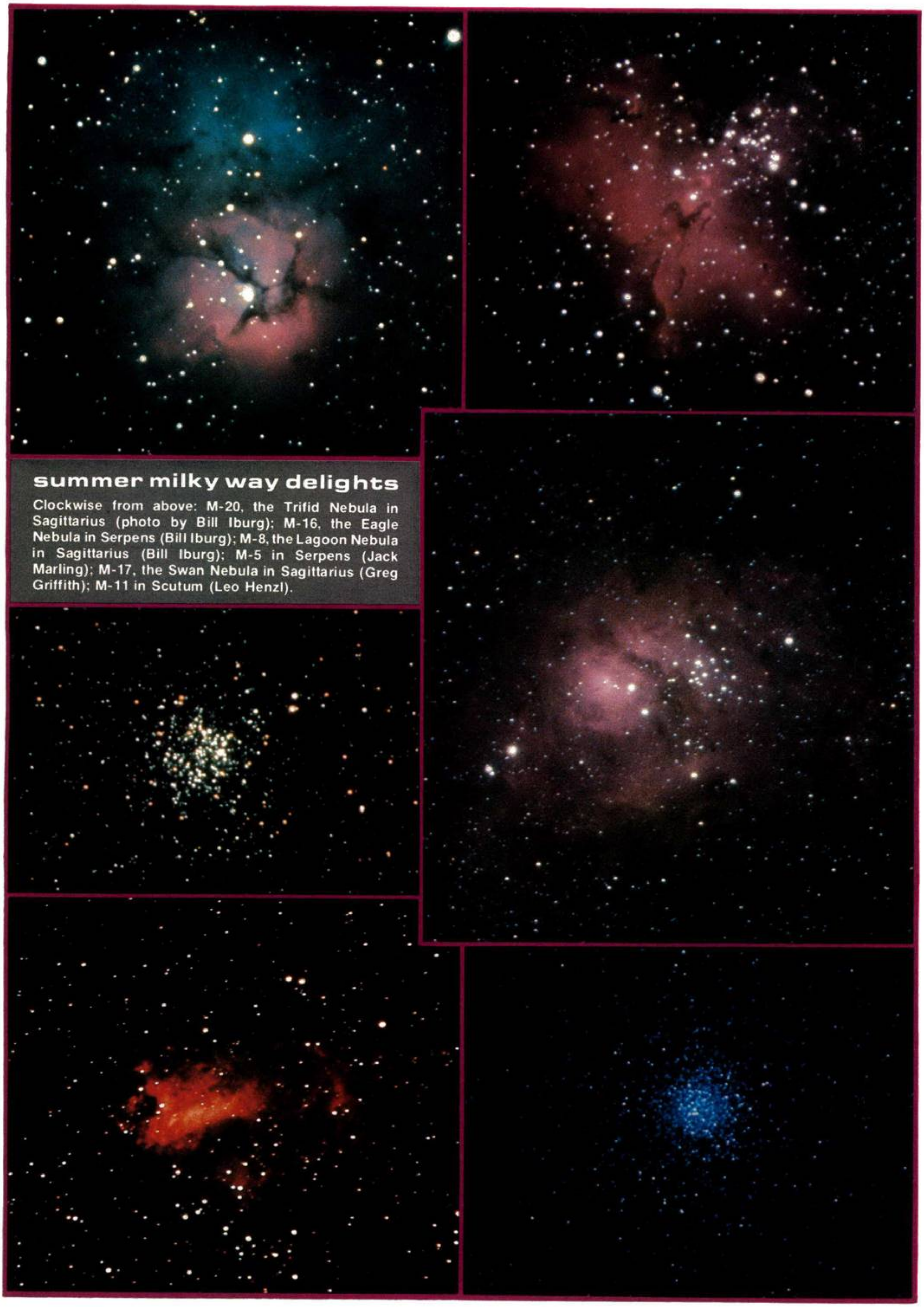
George Chambers noted that it looked like a double-headed shot; the Earl of Rosse thought he saw luminous extensions far beyond the central "dumbbell" mass and believed (erroneously, of course) that he could resolve it into stars. Rev. Thomas W. Webb called it "two oval hazy masses in contact." Kenneth Glyn Jones (observing with a 6-inch reflector) called it "two truncated cones, apex to apex," while John Mallas (using a 4-inch refractor) saw the disk as "almost uniform in brightness."

This underscores a common experience among many deep-sky objects. Small instruments can usually reveal an object to be non-stellar, but apertures of 6-inch or more are called for when you want to discern details of shape and structure.

To find our next object, the open cluster **NGC-6940**, center your scope on Albireo. Then offset 17′ of arc to the north and sweep 1h 4m of right ascension to the east. Use a low-power eyepiece when scanning — finding the fairly broad, 8th magnitude cluster is easy. Keep the power low when observing this cluster; high powers move you in too close and take away the sense of scanning past a thickening in the stellar background.

Sagitta, the constellation immediately south of Vulpecula's western half, measures about an hour and a half of right ascension east-west and 4° or 5° of declination north-south. None of its four or five naked-eye visible stars is brighter than 4.4 magnitude, but all are brighter than the surrounding star fields. As a result, Sagitta is a more prominent constellation than you would expect.

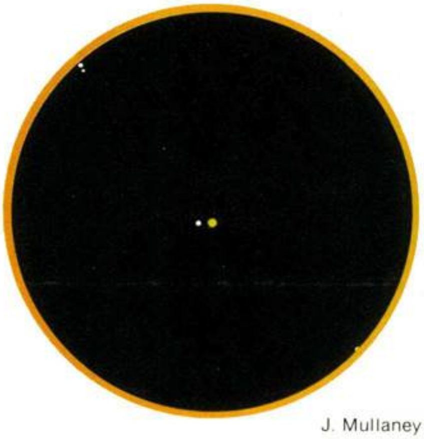
Its prime attraction is **M-71**. This 8.3 magnitude cluster lies halfway between Delta (δ) Sagittae and Gamma (γ), some 3° to the northeast of Delta.



summer milky way delights

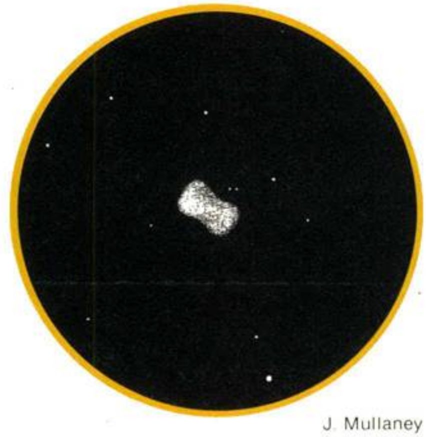
Clockwise from above: M-20, the Trifid Nebula in Sagittarius (photo by Bill Iburg); M-16, the Eagle Nebula in Serpens (Bill Iburg); M-8, the Lagoon Nebula in Sagittarius (Bill Iburg); M-5 in Serpens (Jack Marling); M-17, the Swan Nebula in Sagittarius (Greg Griffith); M-11 in Scutum (Leo Henzl).

Gamma Delphini



J. Mullaney

M-27



J. Mullaney

The cluster's diameter is about 6 minutes of arc.

Easy to find, even in binoculars, **M-27** shows off its best with medium to large instruments and low to moderate-power eyepieces. As Messier described it, "The light is very faint and it contains no star. The least light makes it disappear." Webb's characterization was "large and dim." Many observers have noticed that the western edge of the cluster appears brighter and more distinct than the eastern.

If you extend the line from Delta Sagittae through Gamma about the same distance again, you'll arrive at a pretty "triple" star, **Theta** (θ) **Sagittae**. In your eyepiece, you'll see a 6.3 magnitude primary star (A) and an 8.7 magnitude companion (B) about 12" of arc away to the northwest. A third star (C), with a magnitude of 7.1, lies about 85" of arc to the southeast of A.

Both A and B have a common proper motion and probably form a bound system. But their orbital period must be very great because there has been little or no change in position angle or separation since their discovery about 150 years ago. C's distance from A is steadily increasing and this means its "connection" with the A-B system is probably just a coincidental alignment.

But try comparing the three for color contrasts; their spectral types are different yet closely similar. The A component is F1, B is G5, and C is K2 — and all are in the "dwarf" luminosity class (like the Sun). One of Webb's observations labeled them as yellow-white, ashen, and yellow — and on another occasion they appeared to him as white, bluish, and reddish. When you consider that the A star is slightly hotter than the Sun, B is a near-match, and C is slightly cooler, they *ought* to look yellow-white, yellow, and yellower! How do you see them?

Our next object, which lies just across the border into Sagitta's neighbor to the east (Delphinus), is the small, dim planetary nebula **NGC-6905**. Start looking for it by first locating the 5.3 magnitude star Eta (η) Sagittae (which lies midway between Theta and Gamma) and then sweeping due east 17m of right ascension (4°).

The nebula has a brightness of 10.5 magnitude; its elliptical shape measures about 38" of arc by 44", with the long axis extending northwest-southeast. In a small aperture instrument, you won't see very much of this nebula — even with a 6-incher, the view will be less than impressive. But observers with 10-inch or larger telescopes will find this a beautiful, softly glowing streak of haze. Whatever instrument you use, try averted vision — looking slightly to one side of the object — to make it appear brighter.

Gamma (γ), the easternmost star in the diamond of Delphinus, marks the dolphin's nose and is one of the prettiest double stars in the sky. A presumed binary system with components of 4.3 and 5.1 magnitudes, Gamma's two stars are of spectral type K1 and F7, making one star a little whiter than the Sun, the other a little redder.

We have to assume the system is binary because although the two components share an identical proper motion, like Theta Sagittae there has been little change in their separation and position angle: B lies 10" of arc away from A in position angle 268° — almost due west.

Our last constellation this month is Equuleus the colt. Ranked next to last in size among all the 88 constellations — only Crux (the Southern Cross) is smaller — Equuleus nevertheless dates back at least to the 1st century A.D., when it was mentioned by Ptolemy.

Its attractions are all multiple star systems: you'll find Gamma (γ) is an excellent and easy "binocular double," Epsilon (ϵ) a moderately difficult triple, and Delta (δ) a challenging close pair.

The stars that Johann Bayer collectively called Gamma were cataloged by John Flamsteed as two separate objects and so **Gamma Equulei** also appears on star charts as 5 and 6 Equulei. 5 Equ has a magnitude of 4.6 and 6 Equ, 6.0. On the sky, about 6 minutes of arc separate them, and a pair of binoculars are all you need to show them nicely.

But with a telescope, high powers and steady air will reveal that 5 Equ is apparently a triple system: besides the 5th magnitude primary star (A), there's an 11th magnitude companion (B) only 2" of arc away (almost due west), and a 12th magnitude star (C) some 48" away to the north. The A and B stars share the same proper motion and therefore are likely a true binary pair. The C star does not and is coupled with them only optically.

Delta (δ), which lies just to the east of Gamma, is a binary star system with one of the shortest known periods of revolution: only 5.7 years. The distance between them (according to Robert Burnham Jr.) is only 4.6 AU — less than the distance at which Jupiter orbits the Sun.

If the system were much farther away than its actual 55 light-years, we'd have no chance at all of seeing the two components individually. Even so, it's no cinch. Those with large instruments stand the best chance — but the pair is now near its minimum separation of about 0.1" of arc. If you fail to split them now, keep checking back during the next year or two.

Some star maps (the *Atlas of the Heavens*, for instance) show Delta as a triple system. This is erroneous, for the third "component" — a 10th magnitude star lying to the north-northeast of the A and B pair — has been increasing its separation from them steadily since the system was first observed in 1833. (Moreover, star C has its own proper motion.)

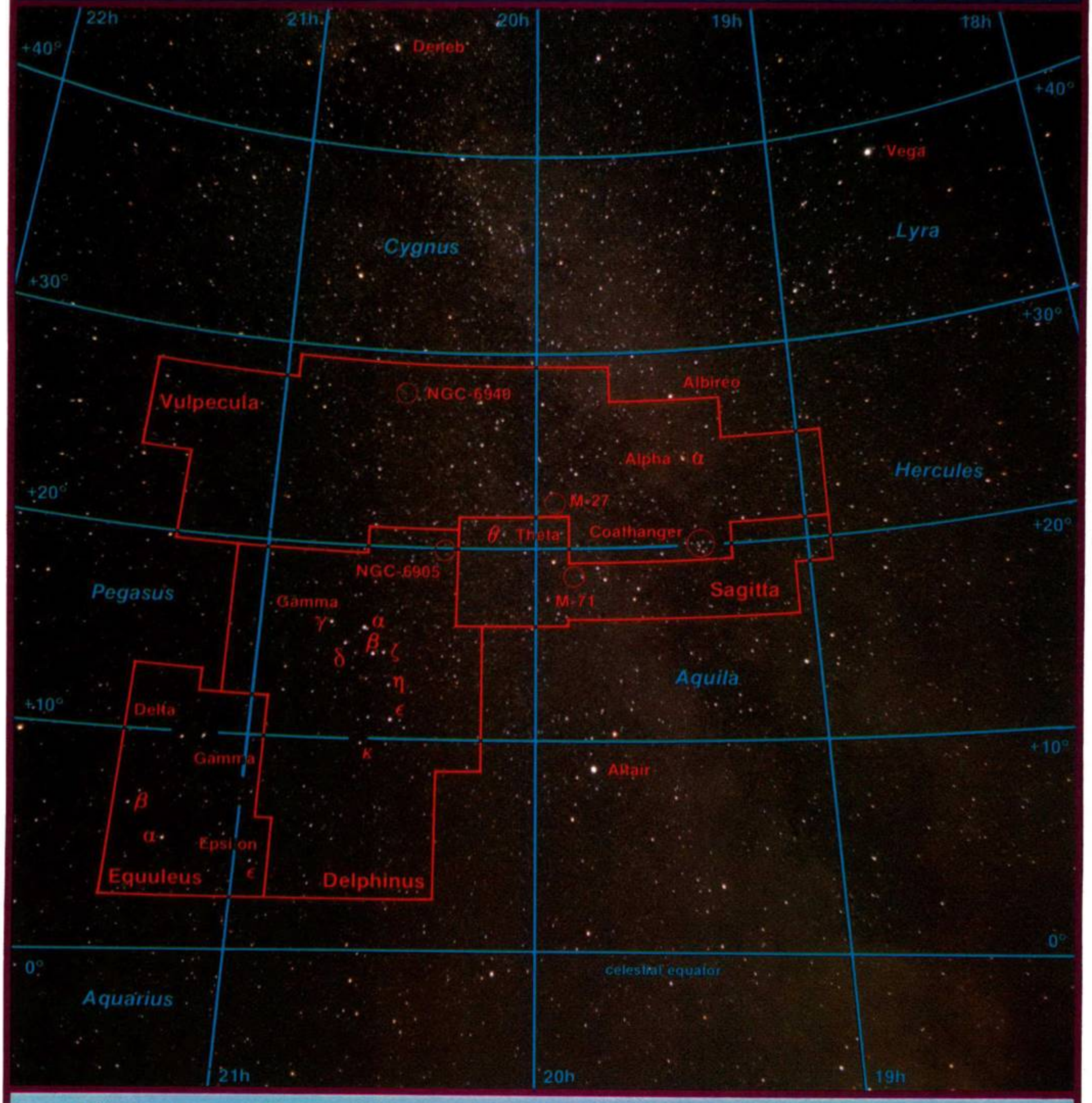
The last object on the tour this month is **Epsilon** (ϵ) **Equulei**, a triple star in the southwestern corner of the constellation. The separation of its A and B components ranges from 0.1" of arc at closest to 1.1" at farthest, over a 101 year period. They were farthest apart in 1970 and are now closing up. The system has a third member (magnitude 7.2) at a distance of some 11" of arc to the east-northeast whose orbital period must be great because little orbital change has been noted.

This month's quartet contains many more objects than we've mentioned here — a good number of pretty binary and triple systems, for example. Though they lack the immense star-clouds found in Scutum and Sagittarius to the south, they abound with other sights. Browse through this sample as a starting point, and then see what you can find in the vicinity of each of the objects we've highlighted.

vulpecula region

photo by Brad Wallis & Robert Provin

map by Robert Burnham


22h
21h
20h
19h
18h
+40°
+40°
Deneb
Vega
Cygnus
Lyra
+30°
+30°
Vulpecula
NGC-6940
Albireo
Alpha α
Hercules
+20°
+20°
M-27
θ Theta
Coathanger
NGC-6905
Sagitta
Pegasus
Gamma
γ
α
β
δ
ζ
η
ε
M-71
Aquila
+10°
+10°
Delta
Gamma
κ
Altair
β
α
Epsilon
ε
Equuleus
Delphinus
0°
0°
celestial equator
Aquarius
21h
20h
19h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (1981)	Dec.
Vulpecula							
the Coathanger	○	5.5	45′x100′	19h24m	+20°00′	19h25m	+20°04′
M-27	■	7.6	4′x8′	19h57m	+22°35′	19h59m	+22°40′
NGC-6940	○	8.2	20′	20h32m	+28°08′	20h34m	+28°14′
Sagitta							
M-71	●	8.3	6′	19h51m	+18°39′	19h53m	+18°44′
Theta (θ)	★^{3}	6.3,8.7,7.1	12″,85″	20h08m	+20°46′	20h09m	+20°51′
Delphinus							
NGC-6905	■	10.5	38″x44″	20h20m	+19°57′	20h22m	+20°03′
Gamma (γ)	★^{2}	4.3,5.1	10″	20h44m	+15°57′	20h46m	+16°03′
Equuleus							
Epsilon (ϵ)	★^{3}	5.9,6.2,7.2	1″,11″	20h57m	+04°06′	20h59m	+04°18′
Gamma (γ)	★^{2}	4.6,6.0	6′	21h08m	+09°56′	21h10m	+10°08′
Delta (δ)	★^{2}	5.3,5.4	0.1″	21h12m	+09°48′	21h14m	+10°01′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
m★	*Regular Variable*
∩★	*Irregular Variable*
Ӿ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*

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